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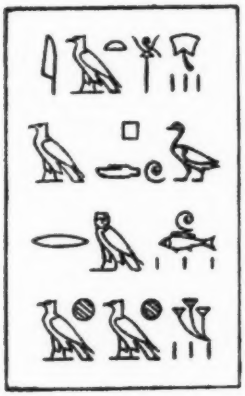
THE JOURNAL OF WILDLIFE MANAGEMENT



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The Journal of Wildlife Management is printed by The George Banta Publishing Co., and published by The Wildlife Society in January, April, July, and October, at 450 Ahnaip St., Menasha, Wisconsin. Sent free to all members not in arrears for dues. Subscription $4.00 per year; single copies $1.00.

Manuscripts for publication, books and papers for review, and correspondence about them should be sent to the *Editor*, Tracy I. Storer, Division of Zoology, University of California, Davis, Calif.

Dues, subscriptions, changes of address, requests for missing numbers, applications for membership, and other correspondence should be sent to the *Secretary*, Pennoyer F. English, 206 Forestry Building, The Pennsylvania State College, State College, Pa.

Entered as second class matter July 12, 1937, at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879.

Articles in this Journal are indexed in the Agricultural Index, available in many libraries.

THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 9 OCTOBER, 1945 NUMBER 4

JAPANESE HONEYSUCKLE IN WILDLIFE MANAGEMENT[1]

C. O. Handley

Virginia Cooperative Wildlife Research Unit, Blacksburg, Virginia

The value of Japanese honeysuckle (*Lonicera japonica*) in wildlife management appears to have been overlooked because of the widespread feeling that the plant is a pest which should be avoided. Uncontrolled fire is dangerous and may be disastrous, but controlled burning may be a useful tool. It is my opinion that in Japanese honeysuckle we have a parallel case—properly used it may be of considerable value in wildlife management.

Its chief value is as an excellent cover, but there is considerable evidence that it is widely used as an emergency food. Cady (1944) found the plant in 124 of 552 crops of bobwhite quail from the Norris Reservoir Area, Tennessee, during the winters of 1938–41, and it constituted 0.87 per cent by volume of the diet. The quantity is not great, but nearly one-fourth of the birds had eaten some, a high percentage of occurrence.

In Virginia, Japanese honeysuckle is utilized by several species. About 1.5 per cent of the food in 559 quail collected between November and January (Baldwin, 1938) consisted of this plant. The food records made by the U. S. Fish and Wildlife Service at the Patuxent Research Refuge include 350 quail crops taken in November, of which 8 per cent contained this species, totaling 2.2 per cent by volume. Mosby and Handley (1943) reported 0.87 per cent by volume of this species in 524 wild turkeys collected in Virginia during November, December, and January; 9.5 per cent of the turkeys had fed on the fruit and leaves. One bird had eaten 1,530 berries, 365 seeds and 28 leaves, and each of several had eaten 200 to 900 berries. On the Cumberland State Forest, Virginia, during zero weather in January 1940 when 26 inches of snow covered the ground, Japanese honeysuckle thickets were much used by wild turkeys. The foliage and berries were the only food known to have been eaten by the turkeys for over a week, and they came through in good condition.

Because of the attraction of honeysuckle tangles for both wild turkeys and bobwhites during periods of stress, when all wildlife may need supplemental feeding, such thickets make excellent locations in which to establish feeding stations. In fact, it proved almost use-

[1] Virginia Commission of Game and Inland Fisheries, Virginia Polytechnic Institute, American Wildlife Institute, and Fish and Wildlife Service cooperating. Ralph B. Nestler, Patuxent Research Refuge, and A. B. Massey, Virginia Polytechnic Institute, made many helpful suggestions in the preparation of this article.

less to establish feeding stations elsewere in areas where honeysuckle tangles existed. Honeysuckle tangles are also used by wild turkeys as nesting sites.

On Jamestown Island, Virginia, in January 1940, Japanese honeysuckle appeared to be the favorite browse of white-tailed deer when 16 inches of snow covered the ground. The deer defoliated the honeysuckle as high as they could reach. Observations elsewhere in Virginia have corroborated this finding, and in some places honeysuckle showed the most browsing by deer of all plant species available.

There are also records of the use of Japanese honeysuckle by deer in Alabama, whence records by the Patuxent Laboratory show the plant constituted 4.5 per cent of the food in 22 November deer stomachs, and 1.3 per cent in 40 December stomachs. Pearson and Burnett (1940) in reporting on 19 early winter deer stomachs from the Black Warrior National Forest, Alabama, found 0.9 per cent of the food to be of this species.

The fruit of Japanese honeysuckle is widely used by both song and game birds. I have seen it eaten by the mockingbird, white-throated sparrow, white-crowned sparrow, song sparrow, and junco. The Patuxent Laboratory food records show that stomachs of 114 robins from the Southeastern States, taken between December and February, contained 0.5 per cent Japanese honeysuckle. On the Patuxent Research Refuge, near Bowie, Maryland, intensive ecological studies of the local wildlife are in progress, and show frequent use of this plant by song birds. The hermit thrush regularly eats honeysuckle fruits, but the mockingbird, bluebird, purple finch, goldfinch, white-throated sparrow, and slate-colored junco, take them as emergency food during periods when little else is available.

The particular value of Japanese honeysuckle is that it remains available during periods of sleet, as demonstrated in notes by Robert E. Stewart at the Patuxent Research Refuge on January 28, 1943, just after a severe sleet storm: "The entire day was spent in the field observing the food habits of birds. Practically everything in exposed locations was covered with a layer of ice one-fourth to one-half inch thick. Only three species of plants were being used as food: red cedar (*Juniperus virginiana*), holly (*Ilex opaca*), and Japanese honeysuckle. The persistent leaves of these three species apparently served as ice shields for their respective fruits so that a large proportion of the latter were free of ice. Large flocks of juncos, goldfinches, and white-throated sparrows were congregated in honeysuckle tangles and feeding on the fruit. Robins were also in such places and presumably eating the fruit. This was the only instance when juncos and goldfinches were observed feeding on the fruit of this species." Similar observations have been made by the writer on several occasions, at Blacksburg and in eastern Virginia.

The actual significance of such emergency supplies as Japanese honeysuckle is difficult to state, but I believe the plant, even merely as food, is of considerable value during critical periods when taken with other foods. Work such as that of Errington (1936) has shown that many fruits, when fed alone to

quail, are not effective in maintaining the weight of the birds. Quail will starve to death on some fruits almost as quickly as if no food were available. There have been no feeding experiments with Japanese honeysuckle, but field observations and chemical analyses indicate that it has some nutritive value for several wildlife species, including the bobwhite, particularly in combination with other foods. Few foods are complete enough to sustain life in the bobwhite for long, but yellow corn (Errington, 1936) is more nearly so than any of the other staples tested.

TABLE 1.—COMPOSITION OF JAPANESE HONEYSUCKLE, CORN, AND TIMOTHY HAY. (percentage analyses, moisture-free basis)

	Corn, kernels[a]	*Japanese honeysuckle fruit*[b]	*Japanese honeysuckle growing vegetation*[c]	*Timothy hay, foliage*[a]
Crude protein	11.01	10.42	9.44	11.39
Fat	4.47	7.86	3.44	3.04
Nitrogen free extract	80.27	69.37	56.65	47.13
Crude fiber	2.64	6.65	21.11	31.00
Ash	1.61	6.10	9.36	7.44

[a] Morrison, 1940. [b] King and McClure, 1944. [c] Hill, MS notes.

The chemical composition of Japanese honeysuckle fruits, and of yellow corn kernels (King and McClure, 1944; Morrison, 1940) are compared in Table 1. Honeysuckle fruit compares favorably with corn as to organic content, but is much higher in crude fiber because entire fruits were used in the analyses. Fibrous seeds normally pass through the digestive system of gallinaceous birds entire when fruit pulp is eaten and are eliminated quickly, whereas the fiber in corn kernels is retained in the gizzard and ground finely for a longer period. When honeysuckle fruit is eaten by the quail, only the pulp is utilized to any extent.

Growing vegetation of Japanese honeysuckle has about the same feeding value as timothy hay (Table 1); the former is eaten during periods of stress by several gallinaceous game birds, and by cottontails and livestock.

It is as protective cover for quail and rabbits that Japanese honeysuckle is virtually unsurpassed. When unsupported it is prostrate and of little value, but when twined over shrubs, small trees, or fences it forms the best kind of a thicket, equalled by few others. Thickets of oak sprouts that retain the leaves during winter, and low-growing conifers with branches that hug the ground are about the only others equally effective for bobwhites during periods of snow or sleet on our quail ranges. These statements apply only where the honeysuckle retains its leaves during the winter, as in Virginia and Maryland. Farther north, the plant survives but the leaves may be deciduous, and its cover value then is greatly reduced.

It is appropriate to mention also some disadvantages of Japanese honeysuckle. Where the plant thrives, as in Virginia and Maryland, it can spread so vigorously in certain situations as to choke out all other low-growing vegetation, including fairly large shrubs and small trees; impenetrable tangles of honeysuckle covering several acres may re-

sult. These thickets are undesirable and difficult to eradicate; to prevent such spread, the plant should therefore be used with great care.

This honeysuckle has been naturalized in the Middle Atlantic States for many decades, but has become a serious pest only in sections protected from periodic burning. Fire is effective in keeping it under control, as are livestock; cattle, sheep, goats, and even horses will browse on it; and in a heavily grazed pasture it becomes valueless for game when kept largely prostrate by the livestock. Here, however, is a key to the usefulness of honeysuckle. It can be kept in check by fire and grazing, and will not stand much shade; hence the plant is not likely to penetrate or become objectionable in any woodland with a closed canopy. Wherever surrounded by permanent pasture, cropland, woodland with a closed canopy, or highway or railroad rights of way, it will not spread and become noxious. In such places, and there are some on most farms, use of Japanese honeysuckle as cover and food for wildlife, particularly bobwhite quail, is recommended. We have planted it in such places on the Quail Demonstration Area on the V.P.I. College Farm at Blacksburg, Virginia, and in 1944–45, as in several previous winters, quail made extensive use of the planted tangles. Japanese clover, Korean lespedeza (*Lespedeza bicolor, L. cyrtobotrya*), corn, lesser ragweed (*Ambrosia artemisiaefolia*), and other staple quail foods adjacent to the honeysuckle tangles make an ideal combination for the bobwhite quail. When the ground is bare, the birds seek a normal existence in the fields, but as soon as snow blankets other food and cover, they return to the honeysuckle thickets.

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BULLSNAKES AND THEIR CONTROL ON A NEBRASKA WILDLIFE REFUGE[1]

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Crescent Lake National Wildlife Refuge in western Nebraska lies in an extensive sandhill region dotted with hundreds of bodies of water and has long been known as an important breeding and resting ground for wild ducks. These lakes vary from small temporary potholes and ponds to large permanent lakes of two or three square miles. The usual depth is from one to four feet, but a few are much deeper. There are extensive bullrush marshes and good hay meadows around most of them (Pl. 12, C)

Studies by the U. S. Fish and Wildlife Service revealed that ducks nesting on Crescent Lake Refuge were subjected to heavy predation by bullsnakes (*Pituophis sayi*). The reptiles were reducing the nesting success to far below that on other comparable refuges in the United States (Kalmbach, N. Amer. Wildl. Conf. Trans., **4**: 591–601, 1939). Of 274 duck nests under observation in 1938, bullsnakes completely destroyed 114 (42%) besides taking some eggs from many others. On 16 occasions they were actually caught in the act of swallowing duck eggs (Pl. 13, C). Accordingly, studies in 1939, 1940, and 1942 included experiments to control these reptiles. Various methods, including pitfalls, poisoned eggs, and glass eggs, were tested but the only successful means was by the live trap here described.

[1] Gilbert E. Wardwell and Gene H. Crawford, successive managers of the Refuge cooperated helpfully in the study.

Natural History of Bullsnakes

Sex Ratio

When the local snakes first emerged in spring, males were more in evidence than females, about three-fourths of those taken in May being males. This may have been due to their greater movements during the breeding season rather than to greater abundance. The females gradually became more noticeable and, in June, captures included more females than males.

During 1940 all bullsnakes handled were sexed, save the newly hatched young taken in the autumn. Trapping in that year began with the first snake activity early in May and continued until the animals entered hibernation in October. Of 597 sexed, there were 313 males and 284 females, or 110 males per 100 females.

Eggs and Young

During the study, 22 bullsnakes containing immature eggs were examined, all in May and June; the latest dates were June 28, 1939, and June 26, 1940. The largest eggs measured $\frac{15}{16}$ by $2\frac{1}{2}$ inches. The average number in 22 snakes was 12.8, the largest set of 23 was in a 56-inch female, and the smallest of 5 in a 42-inch snake. The record of development of the eggs in females (Table 1) is based on records from 11 snakes captured in 1940. From these data and from examination of many snakes in the field, most bullsnakes in the sandhills of western Nebraska evidently laid their eggs during late June

or early July. Surprisingly few young were observed each spring and none at all in 1938. September apparently was the usual hatching time in the sandhills. Also, it appeared likely that many of the young did not survive the first winter.

In 1940 the traps were operated until October 28, when cold weather ended

TABLE 1. EGG DEVELOPMENT IN BULLSNAKES, 1940.

Date collected	Length of snake, inches	Eggs	
		Number	Approximate size, inches
May 14	55	12	$\frac{5}{16}\times1\frac{1}{4}$
20	57	21	$\frac{3}{4}\times1\frac{1}{2}$
20	56	18	$\frac{3}{4}\times1\frac{1}{2}$
20	53	15	$\frac{3}{4}\times1\frac{1}{2}$
20	54	10	$\frac{1}{2}\times2$
31	47	10	—
31	61	15	—
June 3	52	14	—
20	45	7	$\frac{3}{4}\times1\frac{1}{4}$
20	46	10	$\frac{1}{4}\times2\frac{1}{4}$
26	42	5	$\frac{15}{16}\times2\frac{1}{2}$

snake activity; only in this year was trapping continued and the catch recorded in the autumn. Two young were taken in August, but juveniles became abundant during the first week in September. Of 206 bullsnakes caught during September and October, 176 were less than 24 inches in length and most of them only 15 to 18 inches long.

MEASUREMENTS AND GROWTH RATES

Length measurements were taken each year, but not of all individuals; during representative intervals measurements were made of all those captured. The longest was a 68-inch female weighing 2.6 pounds and another female was 66 inches long. These were the only females over 61 inches long. The longest male measured 64 inches, but of 11 more than 60 inches in length, 7 were males and 4 of them measured 63 inches.

As the study progressed, the measurements revealed a rather uniform decrease from year to year in the average length of the adults captured as follows:

Year	*Number*	*Average length, inches*
1938	36	49.5
1939	97	46.4
1940	152	42.6

The term "adult" refers to snakes at least one year old. The younger ones, easily segregated as a distinct size group, are not included in this analysis of average lengths.

Data on the comparative size of the sexes was obtained from 599 bullsnakes which were sexed and measured. The average length of 312 males was 42.8 inches and of 287 females 41.4 inches. The numbers measured and their average lengths in inches were as follows:

	Males		*Females*	
	Number	*Length*	*Number*	*Length*
1939	75	46.3	57	46.1
1940	128	41.2	164	40.6
1942	109	42.4	66	39.5

The measurements recorded in 1939 and 1940 were taken from May to August, inclusive, and those in 1942 during May and June only.

Some information was gathered on the growth rate in nature. The young less than a year old represented a distinct size class. When first observed in September they were 14 to 17 inches in length, and by the last of October some had increased to 19 and 20 inches. The earliest spring appearance by young of the previous year was late in May. They were then 18 to 21 inches in

length. This size group of young was distinctly noticeable throughout the summer, and by autumn they had grown to an average length of about 29.5 inches, most of them being between 27 and 32 inches. Thus, the growth of a sandhill bullsnake during its first year is about 14 inches.

Due to variation in the growth rate of individuals, the identity of the size group just mentioned was lost during its second year, but analysis of many measurements made it appear that they grew about 7 or 8 inches during the second year of life. The yearly increase in length lessens rapidly as the snakes become older, but even large individuals do not entirely stop growing (Table 2).

The growth rate was 2.5 inches per year for the 49- to 54-inch snakes, but only 0.75 inches for the 64.5- to 66-inch reptiles. Plotting and interpreting a graph of the above growth rates makes it evident that about 11 years are required for growth in the wild from 49 to 66 inches in length. Using the same method, together with the known growth during the first two years of life, the age of a 49-inch snake was computed as 5 or possibly 6 years; and a 66-inch snake is believed to be at least 16 years of age.

TABLE 2.—GROWTH OF BULLSNAKES AT LIBERTY IN THEIR NATIVE HABITAT.

Sex	Marked and released		Recaptured		Months at liberty	Growth, inches
	Date	Length, inches	Date	Length, inches		
Female	June 30, 1940	21.5	Sept. 12, 1940	29	2.5[a]	7.5
Male	April 19, 1940	49	May 4, 1942	54	24.5	5.0
Male	May 21, 1940	56	May 4, 1942	59	23.5	3.0
Female	May 25, 1940	64.5	May 1, 1942	66	23.0	1.5

[a] Nearly half of the "active" season.

SUN TOLERANCE

The ability of snakes of several species to endure direct rays of the sun was tested by placing individuals in hardware cloth cages on dry sandy ground. Table 3 gives the mean temperature and time to kill specimens on hot July days in early afternoon (1:00 to 3:00 P.M.), and includes three species besides the bullsnakes to show their comparative resistance. There was a tendency

TABLE 3.—KILLING TIME OF DIRECT SUNLIGHT FOR SNAKES.

Species	*Length, inches*	*Sex*	*Temperature, °F.*	*Minutes until death*
Pituophis s. sayi	45	♂	96	30
	50	♂	96	38
	45	♂	96	40
	41	♂	96	43
Coluber c. flaviventris	43	♀	99	35
	43	♀	99	35
	41	♂	99	65
	35	♂	99	66
Thamnophis r. radix	28	♀	99	25
	27	♂	99	25
	24	♂	99	28
	28	♀	99	38
Heterodon nasicus	25	♀	99	28
	23	♀	99	110
	23	♀	99	116

for the larger reptiles to die first, but no explanation was found for the quick death of one hog-nosed snake. The bullsnakes were killed on a day slightly cooler than that on which the other species perished.

FOOD HABITS OF BULLSNAKES

FEEDING

Feeding experiments with five captives in separate cages indicated that a bullsnake may acquire an "egg appetite" to the extent that it will not eat anything else. One 54-inch snake ate nothing but eggs, although live mice and nestling birds (blackbirds and English sparrows) were offered. It took 10 eggs (1 coot, 1 pheasant, and 8 blue-winged teal eggs) in 10 days. It fed on each of six consecutive days and eight eggs were consumed during that time, two being taken on the third and fifth days.

Glass "nest" eggs placed with these penned bullsnakes were apparently untouched. Such eggs, when force fed to bullsnakes, were regurgitated.

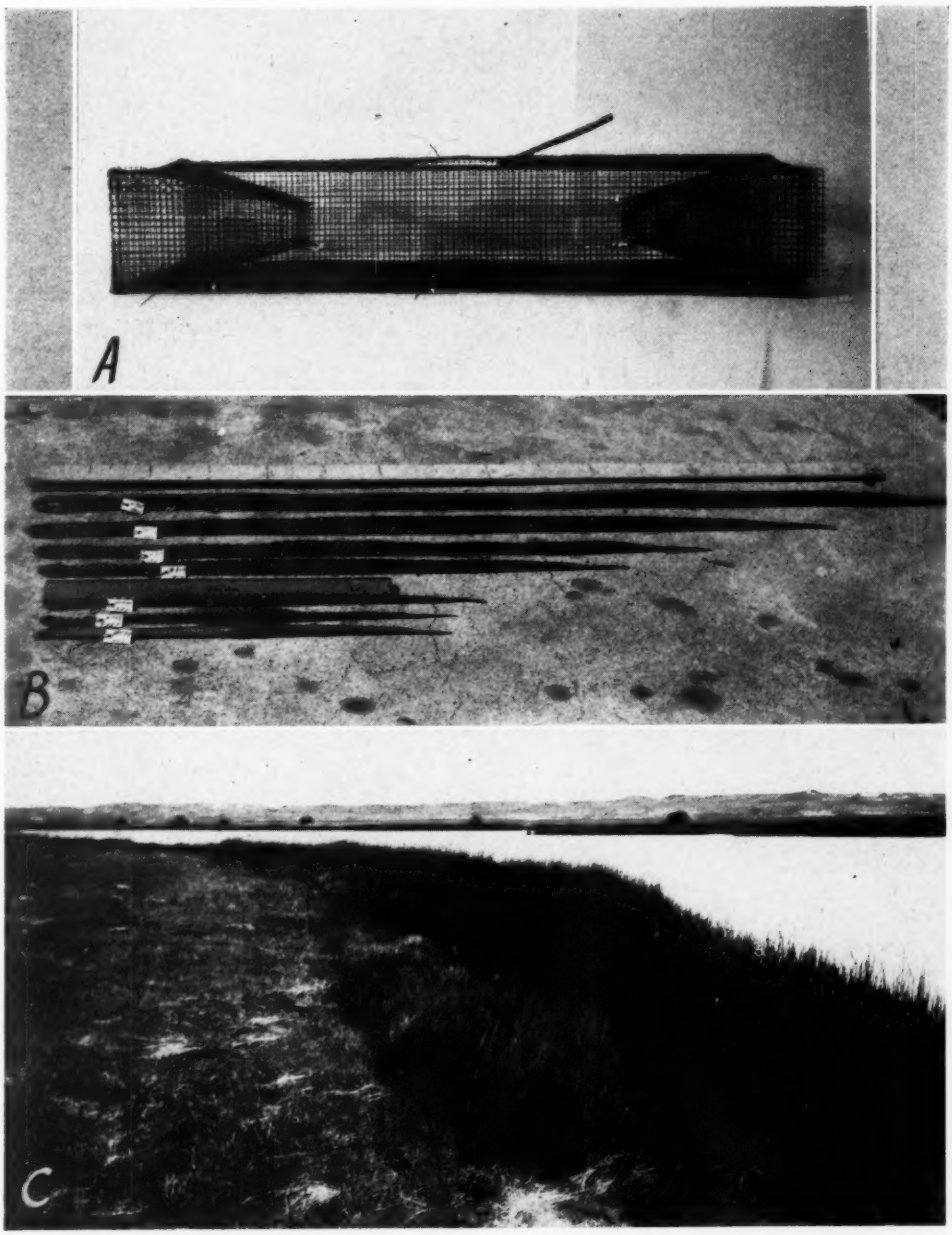
A 35-inch bullsnake swallowed eight adult Peromyscus in one day. Mice were as acceptable as eggs, to most of the captives, but nestling birds appeared to be preferred to either.

On many occasions bullsnakes were observed in duck nests swallowing or attempting to swallow the eggs. After being completely engulfed, the eggs usually are broken in the throat before passing into the stomach. The breaking apparently is done by muscular contractions forcing the egg against a row of bony vertebral processes that form a ventral internal ridge. This ridge is very noticeable in a dissected bullsnake; it begins near the head and extends about 7 inches along the back in a 45-inch snake. A similar "egg-breaking" structure is very highly developed in the African egg-eating snake (*Dasypeltis scabra*).

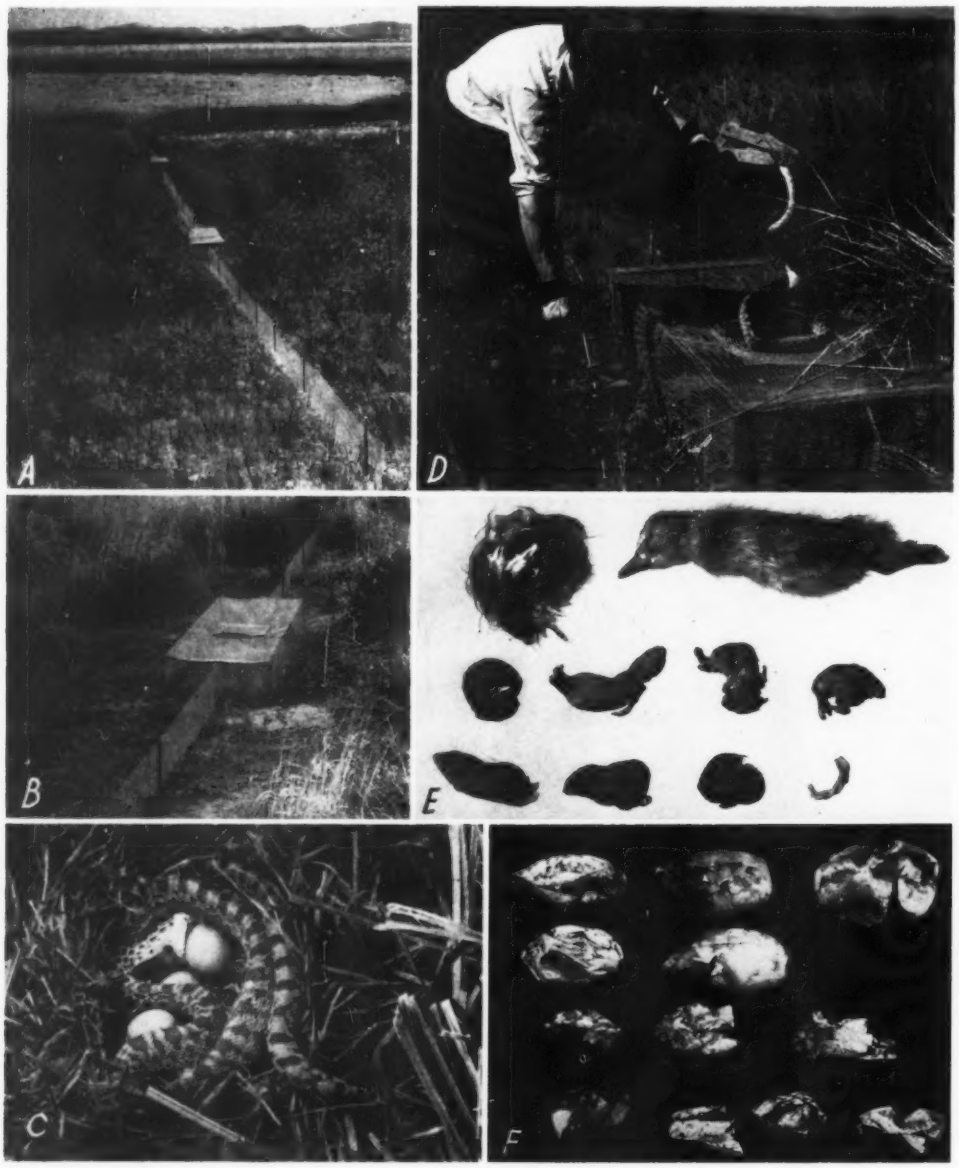
On July 5, 1938, a 44-inch bullsnake was swallowing eggs in a gadwall nest. Subsequent examination of the stomach revealed that the snake was taking its second egg when first seen. As soon as the egg passed out of sight it moved rather quickly to about 5 or 6 inches behind the head; then the snake straightened somewhat and, with tightening of the muscles and a few slightly writhing motions, crushed the shell. The crunching was plainly audible. Then the snake lay motionless for two or three minutes. This entire process then was repeated, but when the snake started to swallow the fourth egg it was taken from the nest and immediately killed. Examination of the eggs in this and many other snakes showed definitely that the first break in a duck egg swallowed by a bullsnake is a longitudinal fissure. As the egg passes on through the digestive tract this fissure usually develops into a deep fold.

In some instances the snakes regurgitated the shells and attached membrans but, since many also were found in the intestines and feces, it appeared that these materials usually passed through the digestive tract. When in the lower intestines and feces the membranes usually were intact but the shell was digested except within deep folds of the membranes.

Newly hatched bullsnakes were not known to feed before their hibernation in the autumn and apparently took no food for some time after they emerged in the spring. In 1940 the young began



A. Side view of live trap for snakes with funnel entrance at either end and door (opened) at top for removing trapped animals. *B*. Seven bullsnakes trapped in early spring; lengths and estimated ages were: 53 inches, 6.5 years; 42 inches, 3.5 years; 33 and 28 inches, 1.5 years; 19, 18, and 17 inches, respectively, young of the preceding autumn. *C*. A lake in the Nebraska sandhills.



A, *B*. Snake traps as set with drift fences radiating from lake shore. *C*. Bullsnake eating an egg in nest of redhead duck. *D*. Removing trapped bullsnake from trap with snake tongs. *E*. Stomach contents of a large bullsnake: 2 adult and 7 young meadow mice, tail of pocket gopher, and a young ruddy duck. *F*. Remains of eggs taken from stomach of 60-inch bullsnake, 5 of gadwall and 7 of avocet.

to appear on May 13 but were not known to have taken food until May 28. In 1942 the young began moving about late in May, but the first containing food were collected on June 13. The first meals of these young bullsnakes were invariably small mice, usually young *Microtus* or adult *Perognathus* (Pl. 13, E).

STOMACH EXAMINATIONS

Stomachs of more than 1,000 bullsnakes were examined; about three-fourths were empty and 254 contained food. Many of the stomachs were taken from trapped snakes, but 111 of those with food were from untrapped bullsnakes (Table 4) collected at random on various parts of the refuge.

TABLE 4.—FOOD OF BULLSNAKES, BASED ON ANALYSIS OF 111 STOMACHS.
(All figures are volumetric percentages)

Year	1938	1939	1940	1942[a]	Totals
Number of stomachs	37	39	12	23	111
Duck eggs	42	17	16	41	29
Other bird eggs[b]	1	13	14	16	11
Nestling birds[c]	14	14	—	3	8
Total birds	57	44	30	60	48
Meadow mice	33	46	41	26	36
Pocket gophers	2	8	14	6	8
Kangaroo rats	5	2	8	—	4
Rabbits (young)	2	—	7	—	2
Other mammals[d]	1	—	—	8	2
Total mammals	43	56	70	40	52

[a] Collections in 1942 in late May and in June, during peak of duck nesting. Collections in 1938, 1939, and 1940 May to August, inclusive. Duck nests most abundant in 1938, scarcest in 1940.
[b] Mostly of meadowlarks and blackbirds, few of avocet, ring-necked pheasant, coot, and marsh wren.
[c] Young blackbirds and meadowlarks and two nestling short-eared owls.
[d] Two harvest mice, two ground squirrels, one shrew.

Mammals comprised slightly more than half of the food, and bird eggs and nestlings supplied the remainder. Snakes which fed on duck eggs usually ate one to three eggs at a time, but occasionally more (Pl. 13, F). Young blackbirds and meadowlarks were fairly common food items but only one duckling was found in a bullsnake stomach (Pl. 13, E). One large bullsnake had swallowed two nestling short-eared owls.

TRAPPING

THE TRAP

The trap employed was 72 inches long, 24 inches wide, and 11 inches high (Pl. 12, A), made of hardware cloth of $\frac{1}{3}$-inch mesh, and having a "funnel" entrance at either end. The entrances were made so that a snake entered by crawling up a slightly ascending plane. The opening at the inner tip of the funnel was 2 inches wide by 3 inches high, and 4 inches from either the top or floor of the trap. An entrance partition (to which the drift fence was attached) extended into each funnel to where the funnel was 4 inches wide, thus dividing the latter into two passages each at that point the same size as the inner tip of the funnel. A hole was cut in the top

of each trap for the removal of captured animals. This was covered with a trap door; later experiments proved that few bullsnakes would get out even when the door was open, but blue racers would almost invariably escape. Some young bullsnakes escaped by crawling through the ⅓-inch mesh wire but none got through a mesh of ¼-inch.

DRIFT FENCES

The drift fences (one attached to each end of each trap) proved a major factor in the success of trapping snakes (Pl. 13, A, B). They were of hardware cloth and of various heights. In sparse vegetation or short grass a fence 8 or 9 inches high would almost invariably turn the snakes, but in dense and taller vegetation the reptiles would occasionally climb over and in the latter type of cover the fence needed to be 12 to 15 inches high.

Most of the trapping was done in meadows along the shores of sandhill lakes. Drift fences usually were placed at a 60-degree angle with the lake shore and varied from 150 to 320 feet in length. The traps (two per fence) were placed at 30 to 60 feet from the ends. The length of fence between the two traps was about twice as great as that beyond each trap.

EFFECT OF TRAPPING

After it was learned that bullsnakes were taking over 40 per cent of the duck nests on the Crescent Lake Refuge, these reptiles were killed at every opportunity. They were plentiful on all parts of the Refuge. We have no means to compute the total bullsnake population but the trapping record for 1940 on Gimlet Lake gave some idea of their abundance on a limited area. This lake has about 70 acres of water and 2½ miles of shore line. It is the best duck-nesting locality on the Refuge. The area had lain idle and been protected from grazing since last used as a hay meadow in 1932. The resulting heavy growth of vegetation made a dense ground cover and microtus were plentiful.

During the summer of 1940 the 27 snake traps set along the shore caught 372 bullsnakes, or 13.8 snakes per trap. Some measure of the effects of trapping is shown by the reduced catches in succeeding years. In May and June of 1940 the 27 traps took 186 bullsnakes, but the same traps caught only 89 during the same months of 1942. They were operated in 1941 by refuge personnel but the catches were not recorded separately. It is significant, however, that 68 traps during 1941 caught only 628 bullsnakes whereas 751 were taken in 63 traps used during 1940 (Table 5).

TABLE 5.—BULLSNAKE REMOVAL ON CRESCENT LAKE REFUGE.

Year	*Traps used*	*Bullsnakes removed by*		
		Trapping	*Other means*	*Totals*
1938	—	—	105	105
1939	27	182	114	296
1940	63	751	89	840
1941[a]	68	628	?	628
1942[b]	53	188	48	236
Totals		1729	356	2105

[a] Figures supplied by G. H. Crawford; no records of number caught by hand.
[b] Trapping ended June 30, 1942.

The effect of the trapping was reflected also in fewer depredations on eggs of nesting ducks. On Gimlet Lake, where bullsnake trapping was heaviest, destruction of duck nests by this reptile decreased from 35 per cent in 80 nests under observation in 1938 to 18.5 per

cent in 27 nests studied in 1942. The bullsnake depredations, as disclosed by the percentage of duck nests destroyed, might have shown still greater decrease if duck nests had been as plentiful in 1942 as in 1938, since there would have been fewer predators per nest. The varying conditions of weather, availability of other foods, and mammal predation on nests, however, complicated the changing picture of bullsnake depredations.

Traps near the lake shore caught more bullsnakes than those farther from water. During 1940 there were 56 traps operated for about 5 months. Those less than 200 feet from the shore averaged 14 bullsnakes per trap, while those farther from the water averaged less than 7 per trap. Similar results were shown by 16 traps in 1939 set in drift fences running to the water's edge. Eight near the water averaged 8 bullsnakes per trap while an equal number farthest from the lake took only 3 per trap. Possibly some of the bullsnake concentration near water may result from the attraction of duck nests which are most abundant there.

Traps set where the ground cover was thin did not take as many snakes as those in denser cover, especially in middle and late summer when the snakes sought more protection from the heat. One trap so placed caught only 3 bullsnakes in 1940 (Pl. 13, B) while two in heavier cover (Pl. 13, A) took 27 during the same period. After these facts were noticed some traps were covered with boards to learn whether this would make them more attractive to the reptiles, but there was no appreciable difference in the number caught by covered and uncovered traps.

To study the migration of bullsnakes, 54 individuals were marked and released during the spring of 1940. This was done by tattooing a number in code on the belly of each reptile; all data concerning a particular bullsnake then were recorded under this number. Of the tattooed snakes, 12 were retaken during the summer and six of them were at liberty for more than a month before recapture—one for 52 days, another 54 days, and a third 74 days. Only one snake was retaken more than 300 yards from where released. This was a female, 21.5 inches long, liberated on June 30; when recaptured on September 12, was 29 inches long and was 1½ miles from the place of release. This is the farthest that any bullsnake was found to have moved.

In June 1940 two large bullsnakes, trapped on Crane Lake and marked with the tattooing needle, were released 3½ miles distant near Gimlet Lake. Both were retrapped in June 1942 near the point where they had been liberated two years earlier. These limited data seem to indicate that the "homing" instinct is undeveloped in bullsnakes.

OTHER ANIMALS IN TRAPS

The first bullsnake traps were put into operation during the spring of 1939, mostly during the third week of May but a few not until early July. They were operated from early spring onward in 1940 and 1942.

Experiments involving 14 man-days of hunting snakes on foot as compared with 24 traps operated concurrently showed that one man for 6 hours daily was the equivalent of 2 to 3 traps for capturing bullsnakes.

The traps were quite indiscriminate,

capturing all sorts of reptiles and amphibians, and small mammals. A few adult skunks were taken, but only the young of jackrabbits and snapping turtles were able to enter the traps. None of the latter two was taken during 1939 but several of each were trapped during the two succeeding years.

The yellow-necked mud turtle was abundant on Gimlet Lake where 119 were trapped. Many of them undoubtedly were "repeats," because all those caught were liberated near the points of capture.

Of pocket gophers 13 were caught; in several instances the nearest burrow was more than 30 feet from the trap where the animals were taken. The small rodents and amphibians actually caught numbered more than those removed from the traps because many were eaten by captive snakes. The presence of these small animals in the traps undoubtedly served to lure the snakes, but their presence was not essential to successful snake trapping. Many bullsnakes with empty stomachs were taken in traps that had captured no other animals.

TABLE 6.—ANIMALS CAPTURED IN 27 SNAKE TRAPS DURING 1939.

	Numbers
AMPHIBIANS	
Tiger salamander (*Ambystoma tigrinum*)	102
Leopard frog (*Rana pipiens*)	2248
Rocky Mountain toad (*Bufo woodhousii*)	225
REPTILES	
Bullsnake (*Pituophis s. sayi*)	182
Garter snake (*Thamnophis radix*)[a]	156
Blue racer (*Coluber c. flaviventris*)	87
Hog-nosed snake (*Heterodon nasicus*)	60
Six-lined swift (*Cnemidophorus sexlineatus*)	7
Spotted swift (*Holbrookia m. maculata*)	4
Banded swift (*Scleoporus u. garmani*)	1
Yellow-necked mud turtle (*Kinosternon flavescens*)	119
Painted box turtle (*Terrapene ornata*)	5
Bell painted turtle (*Chrysemys b. bellii*)	1
BIRDS	
Ring necked pheasant (*Phasianus c. torquatus*)	10
Ruddy duck (*Erismatura j. rubida*)	1
Blue-winged teal (*Querquedula discors*)	1
Coot (*Fulica a. americana*)	1
Marsh wren (*Telmatodytes p. dissaeptus*)	1
Olive-backed thrush (*Hylocichla u. swainsoni*)	1
MAMMALS	
Hayden vole (*Microtus haydenii*)	113
Harvest mouse (*Reithrodontomys a. albescens*)	39
Plains pocket mouse (*Perognathus f. flavescens*)	34
Kangaroo rat (*Dipodomys o. richardsoni*)	30
Striped skunk (*Mephitis hudsonica*)	22
Yellow pocket gopher (*Geomys lutescens*)[b]	13
Grasshopper mouse (*Onychomys l. arcticeps*)	10
Nebraska deer mouse (*Peromyscus m. nebrascensis*)	6
Striped ground squirrel (*Citellus t. pallidus*)	6
Prairie jumping mouse (*Zapus h. campestris*)	4
Spotted skunk (*Spilogale interrupta*)	3
Cottontail rabbit (*Sylvilagus f. similis*)[c]	2
Hayden shrew (*Sorex p. haydeni*)	2
Kansas pocket mouse (*Perognathus h. paradoxus*)	1
Northern Plains mole (*Scalopus a. caryi*)	1
Plains muskrat (*Ondatra z. cinnamomina*	1
Long-tailed weasel (*Mustela l. longicauda*)[d]	1

[a] Includes few *T. s. parietalis*.

[b] One *Thomomys*, 1940.

[c] Possibly two species.

[d] Abundant but usually escaped from traps.

Only 15 birds were caught in the traps during the summer of 1939; these comprised 10 young pheasants, two ducklings (ruddy duck, teal), and one each of coot, marsh wren, and olive-backed thrush. An egg of the western yellowthroat was found in one trap, but the female which laid it had escaped. A complete record was kept of all animals captured in the 27 traps used during the summer of 1939 (Table 6).

SUMMARY

1. Bullsnakes destroyed 42 per cent of 274 duck nests under observation on Crescent Lake National Wildlife Refuge in western Nebraska during the summer of 1938.

2. On the basis of limited evidence it appears that bullsnakes are quite sedentary in their habits.

3. Female bullsnakes containing well-developed eggs averaged 12.8 eggs per snake; few females with eggs were found after July 1.

4. Young bullsnakes were abundant in September, but apparently did little or no feeding until the following spring.

5. Bullsnakes averaged 15 inches long at birth; they about doubled their length during the first 12 months and grew 7 or 8 inches during the second year. The rate of growth became less each succeeding year, but even large snakes continued to increase slowly in length. A 66-inch bullsnake was believed to be at least 16 years old.

6. Males averaged slightly longer than females; but a 68-inch female was the longest specimen found.

7. Of 597 sex determinations in 1940, 313 bullsnakes were males and 284 were females (110 males: 100 females).

8. Exposure to the direct rays of the sun at 96°F. killed bullsnakes in about 45 minutes.

9. Bullsnakes were observed in duck nests on many occasions. After an egg is swallowed it usually is broken in the neck of the snake by pressure against bony processes projecting ventrally from the vertebrae.

10. Stomach examinations of over 1,000 bullsnakes (about three-fourths were empty) disclosed that about half of the food is of small mammals; bird eggs and young birds make the remainder. The two dominant items were meadow mice (*Microtus*) and duck eggs.

11. Rectangular live traps of ½-inch hardware cloth with entrance funnels caught 1,729 bullsnakes in four summers, 372 around a single lake in 1940. The traps were indiscriminate, capturing reptiles, amphibians, and small mammals.

12. The effect of trapping for four years was reflected by a reduction in the loss of nests attributable to bullsnakes, from 35 per cent in 1938 to 18.5 per cent in 1942.

COMPARISON OF ANIMAL AND PLANT PROTEINS FOR YOUNG PEN-REARED BOBWHITE QUAIL

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Bobwhite quail (*Colinus virginianus*) and their closely related cousins of the Old World, the partridges, are primarily herbivorous (Ford, Chitty, and Middleton, 1938; Handley and Cottam, 1931). However, Handley points out that "during the first two weeks of existence, young bobwhites, as with the young of practically all other land birds, consume a much greater proportion of animal food than do their parents. Of the food of 20 chicks under two weeks of age, 83.7 per cent consisted of animal matter, compared with 22 per cent in 154 adults collected during the same period." In this series of examinations, Handley noted that the characteristic high animal diet of the young bird changed to the usual high vegetable diet of the adult during the third week. Ford, Chitty, and Middleton found a similar situation for the partridge chick (*Perdix perdix*), where the animal food for the first week comprised 95.3 per cent; second week, 90.7; third week, 52.5; and thereafter, 3.3 per cent.

Apparently this highly insectivorous diet of quail and partridge chicks during the first few weeks is based on two factors: insects and similar animal life attract the attention of the young birds by their movements; and such creatures can be easily torn by quail chicks into bits of a size suitable for swallowing. According to Handley, young bobwhites in captivity can be taught at an early age to eat practically any suitable food. They learn to eat clabbered milk more readily if it is sprinkled with something they can peck at, such as fine charcoal or bits of clover leaves. Poultry feeds for chicks containing some ingredient such as small flakes of wheat bran are eaten by baby quail in greater quantity than plain foods, apparently because of the presence of objects that readily catch the eye. By the term, "plain foods" Handley probably refers to mashes, in which all ingredients have been ground to a mealy or floury consistency. If so, then any balanced diet that meets the nutritive requirements of quail and is ground to the proper consistency to appeal to the chick and be swallowed easily should be satisfactory for raising the birds, whether or not it contains animal matter.

Methods and Materials

Three experiments were made in 1941 to compare the feeding value of protein supplements of both animal and plant sources on the growth and survivability of bobwhite quail chicks and their efficiency of feed utilization.

EXPERIMENT I

Twenty-four, day-old quail chicks were placed into each of 20 battery brooder units and supplied with feed, water, and grit. In all, 11 growing diets were compared; two, the control diet and the diet containing a combination of protein supplements, were fed to single groups of birds, and the other nine were given to duplicate groups. All

11 diets contained 10 per cent ground red proso millet, 5 per cent dehydrated alfalfa leaf meal, 0.3 per cent vitamins A and D feeding oil fortified, and 1 per cent of a salt mixture (comprising NaCl, 2,000.0 parts by weight; anhydrous ferrous sulfate, 11.0; anhydrous manganous sulfate, 17.0; potassium iodide, 0.2 parts; and anydrous copper sulfate, 0.2 parts). Ground yellow corn, the main cereal of every diet, varied in quantity from diet to diet, depending on the quantities of the protein and mineral supplements used. Ground limestone and special steamed bonemeal were included when necessary to help provide calcium and phosphorus; and a flavin concentrate from the alcohol industries was provided in certain diets low in riboflavin. Thus all diets were so balanced as to furnish 28 per cent crude protein (in harmony with the findings of Nestler, Bailey, and McClure, 1942), 1.1 per cent calcium, 0.7 per cent phosphorus, and comparable levels of vitamins A and D, thiamin, riboflavin, and pantothenic acid. In the diet containing buttermilk as the sole protein concentrate, however, the riboflavin content was unnecessarily high as would be expected, much higher than in the other diets.

An endeavor was made to use only one protein supplement in each diet, but the mineral content of some supplements was a limiting factor. None of the animal proteins could be used as the sole protein supplements because of their high calcium and phosphorus content. All these supplements were supplied in sufficient quantities to maintain the calcium and phosphorus content of the diets at the levels recommended by Titus (1939) for domestic chicks (no studies on the calcium and phosphorus requirements of bobwhite quail having yet been run); and the deficiency in crude protein was made up by soybean oil meal.

The proteins compared were as follows (all figures are percentages):

1. Control. Soybean oil meal, 42.0; dried buttermilk, 16.0.
2. Protein mixture. Meat scrap (55% protein), 5.0; sardine fish meal, 5.0; dried buttermilk, 5.0; soybean oil meal, 31.6.
3. Meat and bone scraps (50% protein), 9.0; soybean oil meal, 38.0.
4. Meat scrap (55% protein), 9.0; soybean oil meal, 37.0.
5. Sardine fish meal, 14.0; soybean oil meal, 26.6.
6. Menhaden fish meal, 9.0; soybean oil meal, 36.0.
7. Dried buttermilk, 67.0; soybean oil meal, 10.0.
8. Soybean oil meal, 48.0.
9. Linseed oil meal, 65.0.
10. Peanut oil meal, 49.0.
11. Cottonseed oil meal, 56.0.

As a test of preference by the quail for these diets, they were placed in separate containers before a group of 45 quail in a separate brooder.

EXPERIMENT II

Twenty-five baby quail were placed in each of 20 battery brooder units with feed, water, and grit. Ten diets were fed, each to two pens. These were the same as used in Experiment I, with two exceptions: that containing 67.0 per cent of buttermilk was omitted and that containing linseed oil meal was modified to contain 27.3 per cent soybean oil meal in addition to 27.3 per cent linseed oil meal. Again preference was deter-

mined by placing all 10 diets in separate containers before a group of 32 birds.

In both Experiments I and II, the chicks were kept in battery units for two weeks and then transferred to outdoor colony brooders.

EXPERIMENT III

Eighteen newly-hatched quail chicks were distributed into each of 15 battery brooder units, and 36 more in a home-made brooder.

Seven diets were fed to duplicate pens, and the control diet to the birds in the home-made brooder. These diets resembled those in Experiments I and II, but in all the calcium level was 1.2 per cent, the phosphorus level 0.85 per cent, and all contained 10 per cent dried buttermilk. The other protein supplements used were as follows (all figures are percentages):

1. Protein mixture. Sardine fish meal, 5.0; meat scrap (55% protein), 5.0; soybean oil meal, 30.0.
2. Sardine fish meal, 14.0; soybean oil meal, 22.0.
3. Menhaden fish meal, 10.0; soybean oil meal, 30.0.
4. Linseed oil meal, 10.0; peanut oil meal, 10.0; soybean oil meal, 27.0.
5. Meat and bone scraps (50% protein), 9.0 per cent; soybean oil meal, 33.5.
6. Cottonseed oil meal, 10.0; peanut oil meal, 10.0; soybean oil meal, 26.0.
7. Soybean oil meal, 44.0 (control).

These birds were kept in the battery brooder units for four weeks instead of two, and then moved to outdoor colony brooders.

In all three experiments both the birds and the feed residues were weighed once each week. The experiments were closed at the end of the fifth week, because the authors were interested primarily in the effects of protein supplements during the first few weeks of life, and there were not enough pens to hold the birds on separate diets after the period of brooding. In Experiment III, however, the birds were held in separate pens according to diets through the eighth week, and their weights obtained again at that time.

RESULTS

EXPERIMENTS I AND II

Survival. With linseed oil meal as the sole source of protein, most of the quail died during the first week, but with equal parts of soybean oil meal, 36 per cent survived through the fifth week. Diets containing cottonseed oil meal and dried buttermilk as the sole protein concentrate carried the quail longer than that with only linseed meal, but proved inadequate as all had died by the end of the fifth week. In a majority, there were no signs of bacterial infection, but every indication that the birds had died of malnutrition. The diets containing cottonseed oil meal and dried buttermilk as sole protein concentrates seemed very unpalatable.

Between the second and fourth weeks, picking occurred throughout the battery units of Experiments I and II, regardless of diet. Increasing the salt content of the diets for a day subsequent to the outbreak checked most of the picking.

Live weights. The lowest weights occurred on diets where the protein supplement was either from vegetable

sources or dried buttermilk. On the other hand, the weights of birds on diets containing fish meal, especially sardine meal, were the highest of all; at the end of five weeks the average was 68 grams on sardine meal and 57 grams on menhaden meal. Of the plant-source proteins, soybean oil meal produced the greatest growth, with average weights of 49 grams at the end of five weeks.

Feed consumption. The lowest consumption was on the diets containing cottonseed oil meal, dried buttermilk, and peanut oil meal as sole sources of protein. For the five weeks the greatest consumption occurred on the diet containing the protein mixture.

Efficiency of feed utilization. There was greater efficiency of utilization on the diets containing fish meal or meat and bone scraps (50% protein) than on the others. That containing meat scraps (55% protein), with or without fish meal, however, was no more efficient than those containing plant protein exclusively.

Selectivity by birds. The selection made by quail, when given a choice of the diets, indicated that those containing fish meal were not as well liked as the control diet with soybean oil meal and dried buttermilk, or that containing peanut oil meal. The diet containing meat and bone scraps (50% protein) was well taken.

EXPERIMENT III

Survival. More chicks survived through eight weeks on the diet containing 14 per cent sardine fish meal than on any other. However, those on the diets containing menhaden fish meal and the mixture of linseed and peanut oil meals lived almost as well.

Weights. The heaviest birds resulted with the "protein mixture," averaging 136 grams. The difference between these and the birds on any other diets, except that with 14 per cent sardine fish meal (average 134 grams), was statistically significant. The three leading groups at the end of three, five, and eight weeks, were those receiving fish meal. Diets containing mixtures of vegetable-protein concentrates gave satisfactory weights (120–124 grams).

Feed consumption. Feed consumption was higher on the diets containing fish meal than on the others.

Efficiency of feed utilization. For the first three weeks, the diet containing 14 per cent sardine fish meal was utilized more efficiently than any of others, and the differences were highly significant statistically.

For the five-week period, the diet with the "protein mixture" showed better utilization than that containing 14 per cent sardine fish meal, but the difference was not significant. The diet containing linseed and peanut meals was equally as efficient as the latter.

DISCUSSION

The reason for some protein concentrates giving better results than others may be found in their adequacy as to amino acids. Corman (1944) maintains that oilseed meals seem generally adequate for ruminating animals as single supplements to cereal grains, but for poultry and gamebirds these supplements, as well as certain animal proteins, are deficient or borderline in amino acids, as follows:

Soybean oil meal: methionine.

Peanut oil meal: lysine, methionine,

glycine, tryptophane, and threonine.

Linseed oil meal: lysine, tryptophane, and glycine.

Cottonseed oil meal: lysine, tryptophane, and glycine.

Dried skim milk: glycine and arginine.

Meat scrap: methionine, histidine, and tryptophane.

Fish meal, on the other hand, is generally adequate in all the amino acids and is generally conceded to excel other animal proteins. It has been shown to improve both meat scrap protein and plant protein for growing poultry, but as pointed out by Corman, "the net effect is intermediate, and not mutual in any sense of the word."

For the most part, poultry give only an intermediate response to the combined proteins of oilseed meals. The most promising practical combination of oilseed proteins, according to Corman, is soybean meal and corn gluten meal (not used in our studies). "Limited study has indicated a mutual supplementary effect for these two proteins based probably upon the surplus of methionine contributed by the corn gluten and needed by soybean oil meal. Here is an instance in which the relatively efficient protein of soybean oil meal is actually improved by corn gluten protein, one of the poorest proteins available.

"Under practical conditions even intermediate protein supplementation may offer important economic advantages. The use of two or more protein supplements contributes palatability features to the ration which under farm or feed-lot feeding usually results in higher feed consumption and increased performance" (Corman, 1944).

SUMMARY

Bobwhite quail chicks, when given a choice of balanced diets in which the essential difference was the protein supplement, showed preferences for one diet containing 49 per cent peanut oil meal, another containing a mixture of 9 per cent meat and bone scraps (50% protein) with 38 per cent soybean oil meal, and a third (control) diet containing a mixture of 16 per cent dried buttermilk with 42 per cent soybean oil meal, in contrast to diets containing sardine meal or menhaden fish meal.

Feeding tests during the first five weeks of life showed that diets containing 14 per cent sardine fish meal consistently gave high live weights, low mortality, and high efficiency of feed utilization. Diets with 9 to 10 per cent menhaden meal produced nearly as good results.

Live weights, survival, and efficiency of feed utilization were markedly better on a diet containing 9 per cent meat and bone scrap (50% protein) than on one with 9 per cent meat scrap (55% protein), but not as good as with diets containing fish meal without meat.

The chicks grew and survived more successfully on diets containing either soybean oil meal or peanut oil meal as the sole protein supplement, than on diets containing either linseed oil meal, cottonseed oil meal, or dried buttermilk as the sole protein concentrate. None of these was as satisfactory as the diets containing fish meal.

All chicks died on diets containing either linseed oil meal, cottonseed oil meal, or dried buttermilk as the sole

source of protein. All three of these concentrates, however, gave satisfactory results, when used as 10 per cent of the diet. In fact, survival and efficiency of feed utilization were nearly as good on a diet containing 10 per cent dried buttermilk, 10 per cent linseed oil meal, 10 per cent peanut oil meal, and 27 per cent soybean oil meal, as on diets containing fish meal.

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TURKEY RESTOCKING EFFORTS IN EAST TEXAS

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The eastern wild turkey (*Meleagris gallopavo silvestris*) furnished early settlers of eastern Texas with delicious food and grand sport, and reduction in the turkey population is cause for concern. Despite the efforts of conservation-minded sportsmen, the stock has continued to decline until only a few small isolated flocks remain. The Texas Game, Fish and Oyster Commission has maintained a force of wardens in eastern Texas for many years, but they have been unable to cope with illegal turkey hunters because the region is densely wooded. Again, public sentiment was not developed to the point where protective laws could be enacted early enough to save adequate brood stock. Official records indicate that attempts at restoration were made as early as 1924 by introduction of the Rio Grande turkey from south Texas, but practically all of them failed. This report details what has been done in recent years to restore the eastern turkey.

THE SOUTHERN PINE BELT

The southern pine region extends westward from the Atlantic Coast to terminate in eastern Texas. Along the Red River it is not more than 30 miles wide. The western edge swings southwest to Henderson County and follows the Trinity River southward to west-central Houston County. There the river turns southeast and the pine area crosses and follows a more direct south-

ern line to the gulf coastal area in lower Harris County. The vegetation in the northern part of this area is chiefly of shortleaf pine (*Pinus echinata*) and hardwoods, and the southern part has the shortleaf, loblolly (*P. taeda*), and longleaf (*P. palustris*) pines, with numerous hardwoods. The area originally occupied by the eastern turkey is shown in Figure 1.

A survey completed in 1936 by the Southern Forest Experiment Station and the Texas Forest Service (Dallas Morning News, 1942), showed 10,552,600 acres of productive forest in the 33 counties of the pine belt, about 60 per cent of the total area of these 33 counties. The main forest types of this region are:

Type	*Acres*	*Percentage*
Longleaf pine	931,400	*8.8*
Shortleaf-loblolly	3,793,600	*35.9*
Shortleaf-loblolly-hardwood	2,531,600	*24.0*
Upland hardwoods	1,422,300	*13.5*
Bottomland hardwoods	1,873,800	*17.8*
Total	10,552,600	

Eastern Texas is traversed by seven rivers, the Red, Sulphur, Sabine, Angelina, Neches, Trinity, and San Jacinto. These and their tributaries still represent areas generally suited for forest-loving species such as the eastern turkey. This region is the most humid in Texas; the average annual precipitation is 55 inches in the southeast and 40 inches in the northern half near the Red River. The entire area has a mean annual temperature of about 65°F.

FORMER RANGE OF TURKEY

The eastern turkey probably was confined to the area forested with pine, roughly that east of the Trinity River, but several counties west of this stream near its mouth are covered with pine and conditions there simulate those farther east; hence these counties should be included as a part of the former range. This area comprises about 40 counties and 30,000,000 acres. The northwestern portion extends over into the blackland belt along the Trinity River to Tarrant County and along the Red River to Childress County. The dominant soil type adjacent to these streams supported forest suited to the turkey. The coastal marshes and prairies of Orange, Jefferson, Chambers, Liberty and Harris counties were never extensively inhabited by turkeys, but there are records of the birds on the prairie within a few miles of the timber. Along the western edge of the range of this subspecies there probably was some over-lapping with the Rio Grande turkey (*M. g. intermedia*) native to south, central, and northern Texas. According to the American Ornithologists' Union Checklist (4th ed., pp. 42–43, 1931), the range of *silvestris* included southern Oklahoma and eastern Texas, and parts of the area along the upper Red River may have been included in the range of this subspecies.

HISTORY

Early settlers considered the native turkey population was inexhaustible, but as early as 1883 some of the more densely settled counties had their last turkeys (Table 1), mainly by overhunting. The most common method of hunting was by a turkey caller, used chiefly during the spring breeding season to lure the birds within gun range. Ingenious traps of all types also were

operated. A unique method with a hunter who wanted a generous supply, but not too sure of his aim, was to bait the birds into a long narrow ditch dug for the purpose and shoot them there.

Spring hunting was practiced throughout the area until practically all the turkeys were gone. The Legislature in 1941 closed the season throughout the pine belt, but this action came too late to save enough birds for a speedy job of restoration.

Formerly the hardwoods of eastern Texas were practically untouched by lumbering, but during the past 30 years considerable oak and other hardwoods have been removed. These trees provide important food and cover for turkeys, and their removal contributed to the decline of the birds. The reduction of the mast-producing trees was probably just as great a factor in elimination of the turkeys as was the thinning effect which made the birds more vulnerable to the hunter.

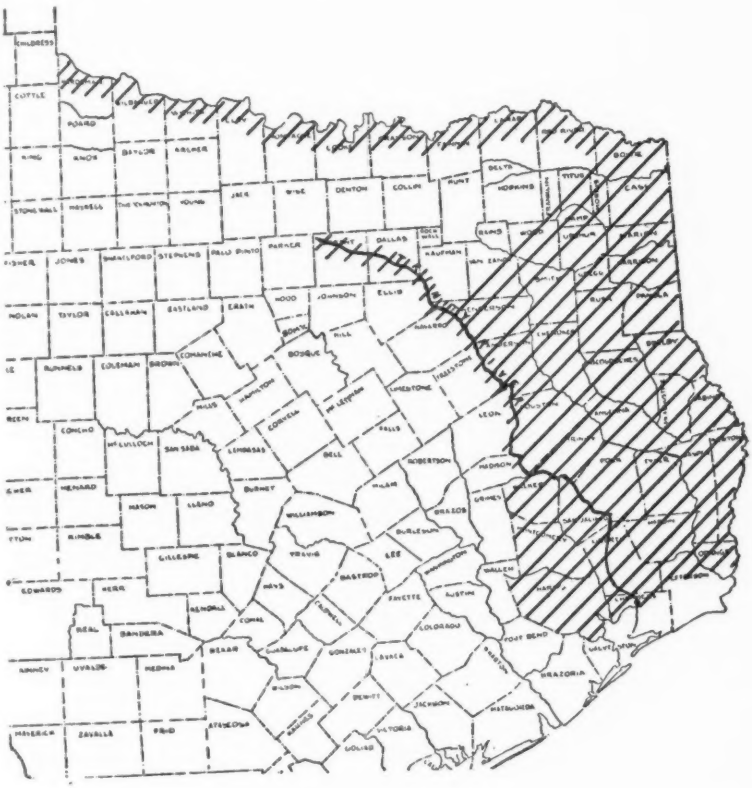

Fig. 1.—Original distribution of Eastern Wild Turkey in Texas (////).

Although the lumber industries have made considerable headway in removing the mast-producing trees and rendering many large areas unsuited for turkeys, there are still approximately

20,000,000 acres that could support a shootable population of these birds. An area with only 50 per cent of timber cover would meet the requirements for turkeys, if composed of food-producing species. Since removal of the virgin forest, subclimax species considered of value for food production such as dogwood, persimmon, ironwood, chinquapin, hackberry, the red and black haws, smilax, and others have increased. The increases of these subclimax species in many areas have made up for the reduction of foods from larger forest trees.

Brushy conditions occur when too much of the original timber has been removed, and often some areas become too dense to be attractive for turkeys. Excessive brush usually comes in on the rich sandy soils that once supported the loblolly-hardwood type. Free-ranging hogs in many sections so reduce the mast supply that even a few turkeys would have difficulty in getting a subsistence ration from this food.

Old time turkey hunters generally agree that hunting was not good after 1918. Hunting in northern and central portions ceased to be good a decade or

TABLE 1.—LATEST KNOWN RECORDS OF NATIVE EASTERN TURKEY IN SOME TEXAS COUNTIES.

County	Place	Year	Authority
Angelina	Angelina River Bottom, Attoyac	1932	C. P. Stewart
Bowie	Red and Sulphur rivers	1910	Hugh Ashford
Camp	Cypress Creek	1910	J. D. Bass
Cass	Sulphur River	1913	R. W. McCoy
Chambers	Old River Bayou	1904	H. Harman
Cherokee	17 mi. n. of Jacksonville	1919	Arthur Sharp
Fannin	Red River Bottom	1888	Mr. Coleman
Franklin	Sulphur River	1919	Wildlife Planning Board
Hardin	Beech Creek at Village Creek	1930	D. W. Lay
Henderson	Flat Creek	1910	A. P. Perry
Houston	5 mi. e. of Crockett	1921	R. R. Stockton
Hunt	Cado Creek	1923	Bill Arnold
Jasper	Boat Lake	1937	Roy Blake
Jefferson	Common sw. of Beaumont; probable kills after 1886	1886	H. C. Hillebrandt
Kaufman	Trinity River, East Fork	1893	A. W. Lewis
Lamar		1883	Gus Cothran
Liberty	Luces Bayou	1932	G. C. Gardner
Marion	Big Cypress	1939	John Markos
Montgomery	10 mi. se. Conroe	1939	W. E. McKay
Newton	Nr. Devil's Pocket	1936	Jim Hicks
Panola		1912	
Polk	Piney Creek, Pate pasture; caught in steel trap	1937	Ed. Proone
Rains	Sabine River	1908	County Wildlife Planning Board
Rusk	Turkeys trapped out	1897	H. W. Watson
Sabine	10 mi. se. Hemphill	1939	Art Scilling
San Augustine	Mouth of Attoyac River	1938	Fischer Osburn
Smith	Nw. part of county	1908	J. H. Mosley
Titus	Sulphur River, Jones Crossing	1913	J. D. Bass
Trinity	Kickapoo Creek	1930	R. R. Stockton
Tyler	Neches River, Wolf Creek	1940	John Knight
Upshur	Big Woods	1918	J. D. Bass
Van Zandt	Koon Creek	1910	Bob Wisdom
Wood	"Big Woods"	1917	Arch Moore

more earlier. A few persistent hunters remained in 1940, and they accounted for practically all of the turkeys left along the more densely wooded streams.

EFFORTS AT RESTORATION

RESTOCKING WITH RIO GRANDE TURKEY

Releases of the Rio Grande turkey (*M. g. intermedia*) in eastern Texas as early as 1924 indicate concern of the Game, Fish and Oyster Commission over the waning population there. Earlier liberations probably were made, but there is no information on this point. A total of 19 releases have been checked (Table 2), and as to success, all but one were complete failures. The exception, that still shows favorable progress, was made in 1939 on the Red River Refuge in Red River County, in the northwestern edge of the pine belt. The same year a liberation was made in similar habitat in Fannin County through the Soil Conservation Service of Fannin County. The birds were placed in an enclosure of about 10 acres and made a favorable increase the first year, but the population dwindled until only a few stragglers remained in the summer of 1942. The birds that escaped from the pen did not receive protection from the hunters and predators as did the Red River stock.

TABLE 2.—TURKEY RESTOCKING TRIALS WITH RIO GRANDE TURKEYS IN EASTERN TEXAS.

Date	County	Place	Number	Results
1924	Harrison	Sabine River near Easton	5	Disappeared by 1933
1927	Walker	Thompson Game Pasture	6	Disappeared by 1935
1932	Panola	Sabine River n. of Carthage	10	Disappeared soon
1933	San Augustine	Mouth Attoyac	—	Disappeared
1933	Harrison	Caddo Lake	36	Disappeared
1934	Angelina	Pine Island Pasture Neches River	14	Disappeared within 3 years
1934	Trinity	Southern Pine Pasture	12	Disappeared within a year or so
1934	Walker	Weiser Bottom	6	Disappeared soon after
1934	San Jacinto	Durden Bend	6	Killed by poachers
1934	Hopkins	Delta-Hopkins Ranch	3	Disappeared soon
1935	Walker	Gibbs Ranch, Trinity River	6	Disappeared
1936	Nacogdoches	Cousins Ranch	5	Immediately killed by poachers
1937	Jefferson	Gilbert Ranch, Fannett	16	No evidence birds remain
1938	Jefferson	Gilbert Ranch, Fannett	24	Dallas hatchery birds, no increase
1937	Walker	Gibbs Ranch, Trinity River	10	Disappeared
1939	Angelina	Perry Club, Neches River	20	Some increase in 1939, none in 1940
1939	Fannin	S.C.S. project	48	Released in pen; practically gone by 1942
1940	Red River	18 mi. n. Annona	68	Still on the increase
1941	Trinity	Southern Pine	45	Never reproduced, some released in pen

A release of 45 Rio Grande turkeys was made in Trinity County in 1941, about half of them being wing-clipped and placed in a 4-acre pen. Within a week all but two hens managed to escape and, so far as could be determined, no young resulted. Similar poor results followed a release of 20 birds (not in a pen) during 1939 in Angelina County. On several release sites, broods were

noted in the first subsequent breeding season, but then the birds began to disappear and by the second season all were gone.

Of all these attempts, 17 were complete failures, one is barely holding on, and that in the Red River area is a success. These attempts indicate that wild-trapped Rio Grande birds find it difficult to adjust themselves to conditions in the pine-oak-hickory type of woodland.

There is no single reason for the inability of the Rio Grande turkey to become established in the piney woods region. One weak point in the program was the small number of birds released, usually 6 to 15. Most recent successful plants in Texas were with larger numbers and frequently more than one release was made on a site.

Another reason was an inadequate sex ratio among the birds. One gobbler to five or six hens is usually considered adequate, but in many past releases the proportion of males was probably less due to non-breeding young toms being included. A ratio of one to eight is satisfactory if the birds are mature and held captive, or if the population is of native stock and well established.

To learn what probably happened in these failures, we may visualize a band of 30, five gobblers and 25 hens, released on a new and different habitat; the factors influencing their success or failure would include:

1. The normal wandering of newly released turkeys, resulting in some birds being isolated at breeding time.

2. Such wandering would render an individual more vulnerable to predators, especially since it is in a strange habitat.

3. Since there often is lack of proper attention to the sex ratio of released wild-trapped turkeys, half of the gobblers released often are only one year old, hence not of breeding age. Unlike hens, the gobblers do not mate until the second year (H. S. Mosby and C. O. Handley, 1943, The Wild Turkey in Virginia). This automatically reduces the sex ratio from 1:5, to 1:12.5, which the present writer considers inadequate, as any release should have not less than 50 per cent mature gobblers.

It is thought that one and probably all three of these factors contributed to the failure of planted turkeys in the pine belt. Favorable results might be obtained by repeated liberations of large numbers on the same area.

RESTORING NATIVE EASTERN TURKEY

A few native turkeys were reported on several areas in the pine belt in 1939. These areas were investigated to determine which were best suited for restoration work and three were selected, one each in Hardin, Newton, and Polk counties. In 1941 the Division of Wildlife Restoration enclosed the 20,000-acre Devil's Pocket Refuge in Newton County by a fence. Reports of turkeys on or near the refuge were confirmed in the spring of 1942 by the keeper and other persons. The refuge and adjoining area were patrolled closely to prevent illegal hunting. By late autumn of 1942, four bands totalling 45 birds had established themselves on or within eight miles of the refuge; in 1943 these had increased to approximately 125. A band of eight around Montgomery Island in the spring of 1943 had increased to 20 by January 1944.

The Piney Creek Refuge in Polk

County supported an estimated population of 25; no marked increase was noted because of poaching on the small remnant. After 1941, no evidence of the birds was found.

PEN PROPAGATION

Since restocking with southwestern birds had failed, pen-reared eastern birds from Mississippi and Alabama were tried on the two areas just mentioned. One hundred were placed in a 19-acre pen on the Big Thicket project in Hardin County late in the autumn of 1940, and 41 more in December 1941.

These turkeys have been observed closely for three breeding seasons and two plans were tried in producing young. During 1941, all hens were permitted to lay, set, and hatch with no human interference but this proved unsatisfactory, because predators took a heavy toll of the eggs. During 1941 and 1942 artificial propagation was practiced, but after about June 1 no eggs were removed from the pen, the hens being permitted to incubate any produced thereafter. The size of the pen was reduced from 19 to 10 acres in 1942, and to six acres in 1943 to facilitate daily egg collections. The eggs were incubated in a commercial hatchery and the poults returned to the refuge for brooding.

FIRST SEASON, 1941

Second-generation pen-raised Mississippi wild turkeys, 48 in all, were released on the Big Thicket area on November 28, 1940, each being banded and having the primaries clipped on one wing before release. The habitat inside the pen was about equally of open field and of pine-hardwood timber with dense underbrush, the latter traversed by several old roads and trails. The open field was planted to crops that would furnish grain and greens for the birds. Laying mash was fed beginning in late February. To eliminate fighting among males during the mating season, 15 gobblers from the laying pen were placed in another fenced area nearby. The original breeding stock consisted of 38 gobblers and 58 hens.

The first egg was found on April 17 and the last nest on July 11. The location of the nests had definite relation to predation and nest mortality. Those least subject to predation were either in isolated brush piles or in the open fields.

The 27 nests under observation contained a total of 360 eggs, the number in each varying from two to 32 eggs. This was an average of 13.3 eggs per nest and 6.4 eggs per hen. About 70 young (19.4%) hatched, and poult mortality was extremely low. Despite excessive rains, the loss of only three was noted. Seven or eight hens escaped over the 8-foot fence with their broods, which then were able to fly. No check could be made on mortality among the 40 or 50 that followed the hens. Of the 27 nests, only two were undisturbed, either before or during incubation.

SECOND SEASON, 1942

The remaining turkeys were augmented by 6 males and 35 females purchased in Alabama, giving a total of 50 hens and 23 gobblers for the beginning of the second season.

Active mating began about March 15 and the first nest of eggs was found March 23. During the period (March 23 to June 1) when eggs were gathered

for artificial incubation, 1,301 were known to have been laid; 70 were known to have been lost to predators and by breakage in handling. From 1,231 eggs placed in the hatchery, 885 poults were obtained, a hatch of 71.8 per cent. Unfortunately fire destroyed the brooder system and most of the poults on June 18.

After June 1, approximately 485 eggs were laid and incubated naturally in the pen, from which 223 poults hatched. Predators were responsible for the loss of 149; 43 failed to hatch and hens deserted 70. A close check on these broods revealed that about 65 died of various causes. Three hens escaped with their broods and a few from other broods may have followed them into the woods. From the known hatches, only five juveniles remained in the pen at the end of three months and an estimated 158 poults, hatched in the pen, escaped to the wild. Tracks and feathers were observed just outside the pen on several occasions, either from birds in the pen or from the few birds liberated when the brooders burned.

A total of 1,786 eggs was produced by the 50 hens, each layer averaging 30.7 eggs for the entire laying season. This was in decided contrast to results in the previous year when artificial incubation had not been practiced and only 6.4 eggs per hen were obtained. Picking up the eggs each day increased production by 472.3 per cent.

Twenty-five one-day poults weighed 2 to 2.25 ounces, averaging 2.20 ounces; by the end of a week they averaged 2.75 ounces, but one weighed only 2 ounces and another 3 ounces.

THIRD SEASON, 1943

The breeding season was started with 28 hens and 10 gobblers in a six-acre pen, of which about four acres was open field and not suited for early nesting. The feeding of laying pellets was started on February 16 and artificial propagation, as employed in 1942, was continued. The first nest was found on March 26 and production was at a peak by the second week of April. The total of eggs collected for the season was 770; of these 12 were culled because of soft shells, poor shape, and breakage, and 758 placed in the incubator. Predators accounted for about 40. The 28 hens produced 810 eggs, an average of 28.9 eggs per bird. These figures do not include eggs produced after artificial incubation was discontinued.

Due to inactivity of the gobblers, about 20 per cent of the eggs placed in the hatchery were infertile. Another 30 per cent of the eggs failed to produce young strong enough to get out of the shell and 4 per cent died immediately after emerging. The hatch of 46 per cent was poor when compared with 71.8 per cent in the previous year.

A new brooder house was constructed and divided into four units. Each had a Blue Flame brooder with a 52-inch canopy over a hardware cloth floor, and an extension (without wire bottom) for the poults to range out in the sunshine. Each unit had about 72 square feet of floor space. Mortality was extremely low for the first six weeks, when only 14 poults were lost, two being mashed by the attendant. Blackhead from infected soil in the laying pen probably was brought into the brooder on the feet of the caretaker. The first poults infected were seven weeks old. Thereupon sanitary conditions were rechecked: all feeders and fountains were sterilized with a torch weekly, accumulations of

droppings, feed, and other debris were removed and the wire floor sterilized by burning, and a flushing medicine was fed each week for three weeks. These precautions failed to stop the mortality and within a few days the disease spread to the other brooders. The two- and three-week poults apparently had more resistance than the older birds. Because of this disease, all birds over eight weeks of age were liberated immediately.

RELEASES

An initial release of 113 poults was made, of 8- and 10-week birds, near an excellent water supply on the Devil's Pocket Refuge. A mixture of small grains was fed daily so long as the birds returned to the point of liberation. After the third week, none returned. Six weeks later bands of four to ten were seen more than a mile from the point of liberation, and two months after the release, 32 were counted in eight different bands. Only a few individuals were seen thereafter, although a goodly percentage may have remained in the area but escaped observation.

The last poults, 35 in number, when seven and eight weeks old, were released on a beech hammock near the pens where they had been brooded. A grain mixture was fed for a few days, but the birds were never seen again, probably having merged with a wild band in the vicinity.

The daily collection of eggs in the pen was discontinued on May 25. Some hens continued to lay and were permitted to incubate their eggs; about 40 young were raised. The poults liberated plus those raised in the pen totalled 188. Egg production was greatly reduced by the daily collection program, but, the chicken snake (*Elaphe obsoleta confinis*) and common crow remained the chief offenders in lessening the yield.

MANAGEMENT OF CAPTIVE WILD TURKEYS

Prime factors in the management of a wild flock held captive for propagation are as follows.

1. The site for the pen should include a variety of habitat, such as brush, open timber, and open fields, and the soil should be friable and well drained with a permeable subsoil; pools of stagnant water are undesirable.

2. The fence should be seven to eight feet high and a two-foot width of wire should be added on the outside, flat on the ground with six or eight inches up against the main fence to exclude predators. Common 2-inch mesh poultry netting is satisfactory. All trees that touch or lean over the fence should be removed.

3. If a flowing stream is not available for water, a well with a metal or wooden trough will suffice. The trough should be emptied and sterilized weekly.

4. Feeders should be rain proof and light enough in weight for ease in moving, to prevent contamination of any one area.

5. Within the main fence there should be a small pen to facilitate capture and handling of the brood stock for banding, wing-clipping, and vaccination.

6. The main pen should be subdivided by cross fencing, arranged so that water can be provided in each unit and the birds can be rotated from one to another without having to cross a second pen. Rotation is one of the most important sanitary practices.

On the open area some winter greens should be planted to aid in supplying

the flock with the necessary balanced diet. In southeastern Texas oats and rye grass are the most desirable; wheat, barley, vetch, and winter peas have been tried with little success. Generally, the mature grains can be supplied more economically in feeders than being raised within the pen. To maintain health and vigor in the turkeys, peanuts and chuffas should be planted to encourage the birds to scratch and obtain sufficient exercise.

The feathers on one wing of each bird should be clipped during January and again about mid-August. It is usually unnecessary to clip the wings of mature gobblers as they are too large and heavy to do much flying.

Low pole roosts are desirable and can be provided by tying poles to trees. If the turkeys are slow in learning how to get on to a roost, a step ladder can be provided by leaning two poles against the roost about six feet apart and tying on horizontal poles for steps.

Proper management of the gobblers is important for production of fertile eggs. Second year males need little attention, but the older gobblers should be separated from the hens at least two months prior to mating time. If left with hens throughout the year, there will be inattention to hens and constant fighting during the mating season. Only one or two gobblers should be left in the laying pen at one time. Feed for the segregated males should be greatly reduced; trough-feeding should be stopped and the birds made to scratch for their feed in the leaves, grass, and weeds. The response of the hens to the one or two gobblers left with them is an accurate gauge to the proper time to introduce more males. An ideal way to manipulate a brood flock would be to divide the gobblers in two groups and rotate them in the pen with the hens every three days. Often this is not possible because the act of separating the birds produces too much disturbance in the laying pen. The wild turkey is easily excited and often becomes impossible to handle when molested. Often it requires three weeks or more of baiting and maneuvering to get a flock in a small pen for wing clipping. If possible, yearling gobblers should not range with the hens during the mating season as their presence often infuriates the mature gobblers and leads to fighting.

In the autumn of 1941, six gobblers were removed from a pen holding about 40 hens and 16 gobblers. These gobblers ranged within a half mile of the brood pen and when the mating season approached they remained close to the pen trying to get to the hens. The gobblers with the hens showed no desire to mate although the hens did. One morning the six outside gobblers were permitted to enter and within a few minutes each was tredding a hen. A high per cent of egg fertility (71.8% hatch) was obtained that season. During 1943 the hens produced many infertile eggs and the hatch was only 46 per cent. The gobblers had not been managed properly; because of difficulty in handling, they were not isolated until a week before the hens showed desire to mate (middle of March). Segregation of half the males failed to stop fighting among the gobblers remaining with the hens. The birds removed for a week were as ready to fight as ever when permitted to re-enter the pen, not having been isolated long enough. Excessive weight

in gobblers also inhibits breeding activity, and some of the lack of success in that season doubtless was due to feeding too much grain during the winter.

DISCUSSION

The turkey hatchery has been abandoned and there is some doubt as to the advisability of further attempts at restocking with pen-raised stock; thorough trial would require a modern hatchery. Natural incubation and brooding in a pen also failed. Likewise, artificial incubation and brooding without complete facilities produced too few birds to be worth the cost or to indicate the success of birds after release.

Wild-trapped birds, used in large and repeated plantings, with an equal sex ratio, would seem to offer better opportunity for restocking even if this required introduction of the Rio Grande turkey into former range of the eastern race. Neither pen propagation nor the introduction of Rio Grande birds is as certain of success as is the management of native birds where present—as in the Devil's Pocket Refuge.

SUMMARY

1. In eastern Texas the southern pine belt terminates its western extension with an area of 10,552,600 acres of productive forest land in the State. This area is drained by seven river systems: Red, Sulphur, Sabine, Angelina, Neches, Trinity and San Jacinto. The rainfall ranges from 40 inches in the north to 55 inches in the southeast.

2. The western extension of the range of *Meleagris g. sylvestris* conforms roughly to the pine belt. Native turkeys were gone in some counties of this region by 1883, but a few still have remnants. The last authenticated kill was in the spring of 1940.

3. Causes for depletion of the turkey population include over-hunting, competition by free-ranging hogs, and removal of suitable habitat by logging.

4. Nineteen liberations of the Rio Grande turkey have not bolstered the dwindling turkey population in eastern Texas, but larger plantings with proper sex ratio might be more successful.

5. In 1941, 100 pen-raised eastern turkey birds from Mississippi were placed in a 19-acre pen and permitted to lay, incubate, and raise the young without human interference. In 1942 eggs were collected daily, incubated at a commercial hatchery, and the poults brooded until 12 weeks of age. The same procedure was followed in 1943 and some young were liberated.

6. Mating is usually well under way by the first week in April.

7. During 1941, 360 eggs were laid, an average of 6.4 per hen; 80 poults were produced.

8. The 1942 season was more successful; 50 hens produced 1,786 eggs or 31.7 per hen. From 1,231 eggs placed in the hatchery, 885 poults were hatched, but 485 were lost in a fire; about 132 were rescued.

9. In 1943, the hens averaged 28.9 eggs; 758 eggs were incubated and 352 poults produced, but due to an infestation of blackhead only 140 were raised to eight weeks of age.

10. The gobblers should be held separately from the hens for at least six weeks prior to March 1. A laying mash should be fed the hens from February 1 onward but the feed should be reduced for gobblers.

BREEDING POTENTIAL AND ARTIFICIAL PROPAGATION OF THE SNOWSHOE HARE[1]

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In a recent paper on the life history of the snowshoe hare (*Lepus americanus*), the writer (Severaid, 1942) described a successful attempt to propagate the subspecies *virginianus* and *struthopus* under game farm conditions. Some additional data were obtained through continuation of that project, and the present paper is a supplement to the 1942 publication. References are made here to aid the reader in correlating the new data with those of the original study during the 1939 and 1940 seasons.

Breeding Potential

MATING SEASON

Snowshoe hares produce young from April to August (œstrum) and go through a nonbreeding period (anœstrum) from September to March. The most recent explanation for this sexual cycle has been advanced by Lyman (1943), who reports that it responds to manipulation of the light cycle in the same manner as described for numerous other mammals, an increase in the amount of daily illumination producing œstrus and a decrease anœstrus. In the latitude of Maine (45° N.) this species begins courtship behavior late in February, but observations indicate that the majority do not mate successfully until the latter half of March or early in April. The earliest recorded birth during this study was on April 17 and the latest on August 29.

GESTATION PERIOD

The gestation period for 37 females ranged from slightly under 36 days to 40 days and averaged 37.2 days during 1939–41. Nineteen females observed during 1941 were pregnant about 1½ days longer than 18 in the two previous seasons.

SIZE OF LITTERS

Large litters were more common in 1941 than in preceding years and included nine of five young and one of six. The average for 80 litters was 2.96 young. (This figure includes four unborn litters; the average was 3.06 for the 76 born alive.) The distribution of litter sizes was as follows: 7 with only one leveret; 19 with two; 25 with three; 15 with four; 9 with five; and one with six. Combining these data with those of the previous two seasons—a total of 157 litters—gives the following distribution: 17 litters of one; 34 with two; 57 with three; 38 with four; 10 with five; and one with six.

Data for both 1940 and 1941 showed that the average litter size increased as the breeding season advanced. Litters with four leverets are consistently more common for the second and third

[1] Contribution from Maine Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, American Wildlife Institute, University of Maine, and Maine Department of Inland Fisheries and Game, cooperating.

Howard L. Mendall, helped in preparing this paper and Eldon R. Clark aided by carrying on the project during the writer's absence late in 1941.

litters or litter periods. The combined data revealed 7 females with one leveret in the first litter of the season, 21 with two, 23 with three, and 6 with four. In second litters, only 5 females had one leveret, 3 had two, 13 had three, and 12 had four. In the third one female had one leveret, 3 had two, 7 had three, and 11 had four. There were equal numbers containing two to five young each during the fourth litter period.

An analysis of average litter sizes by months, 1940–41, shows even more clearly the increase in size as the season advanced: April, 2.47; May, 2.67; June, 3.24; July, 3.38; and August, 3.42. Litter sizes by breeding periods, for both years (see Table 2 for 1941 data alone) were consistent. The combined data showed an average of 2.56 leverets for the first litter, 3.33 for the second, 3.35 for the third, and 3.50 for the fourth.

Because of the small size of the first litters in spring, there appears a possibility that the activity of the ovaries is reduced during the winter as in the testes of males (1942: 24, 20). Further evidence substantiating this theory was obtained in 1941 when 10 pen-raised females born in 1940 averaged 2.6 young per litter for their first 1941 gestation period, whereas 13 others known to be in at least their second breeding season averaged only 2.7 young per litter the same year.

From the review of the literature (1942: 26) and the results of the present study it is likely that 2.9 young per litter is a reasonable average for this species over the greater part of its range and also for its entire breeding cycle.

LITTERS PER SEASON

Approximately three-fourths of all hares in captivity will rebreed on the day of parturition, and four litters per season therefore are possible for this species. During 1941, six females (37.5%) conceived four times, but two died before the fourth parturition.

Because of deaths and frequent liberations of breeding stock during 1941, only 16 females were carried through the season as test stock. All conceived during the first breeding period, 87.5 per cent conceiving two or more times, and 56.25 per cent three or more times. The average number of litters per season for these females was 2.75 as compared with an average of 3.0 in 1940.

BREEDING POTENTIAL

An analysis of the 1940 data (1942: 27) showed an average optimum of 9 young per female was possible for that season, although 8.64 was a more probable potential. The accuracy of these figures became apparent during 1941 when 135 live young were obtained (plus 4 mature embryos from a female which died while pregnant during the fourth breeding period) from the 16 females; an average of 8.7 per female per season.

ARTIFICIAL PROPAGATION

Under proper conditions snowshoe hares readily adapt themselves to confinement and breed satisfactorily. It has previously been suggested (1942: 86) that "If methods could be developed whereby coccidiosis could be eliminated as a mortality factor under domestic conditions about 80 per cent of the young stock can be expected to survive the weaning period." The following results substantiate this statement.

MORTALITY OF YOUNG

Early in the spring of 1941 the pens were remodeled to incorporate all improvements found desirable after two years of research. They were made vermin proof and equipped with wire bottoms, in an effort to reduce deaths from coccidiosis. Sufficient breeding stock was available so that some hares were placed in pens with ½-inch mesh wire bottoms and a few in pens with 1-inch mesh. The remainder, as controls, were left on the ground. Mortality rates for these experiments (Table 1) show 68.3 per cent survival in pens with ½-inch mesh as compared to only 11.6 per cent of those born on the ground in pens used the previous year. Mortality was practically complete in pens having bottoms of 1-inch mesh as the newly born young fell through the wire and soon died.

High mortality was expected among the early litters (Table 2) as many young were still being born on the ground or on 1-inch mesh. Also contributing to higher mortality in early litters were the "still-births," more prevalent among early litters than later ones. Coccidiosis caused some deaths even among hares born on wire as the females frequently were moved from the ground to the wire-bottomed pens a day or so prior to parturition and could therefore pass the disease to the young. The second and third period litters were all raised on ½-inch mesh bottoms by females which had spent the entire season in such pens.

TABLE 1.—MORTALITY AND SURVIVAL OF YOUNG HARES DURING 1941 ACCORDING TO PLACE OF BIRTH.

Type or place of birth	*Born*	*Died*	*Survived*[a]	*Percentage survived*
On ½-inch wire mesh bottoms	101	32	69	*68*
On 1-inch wire mesh or on ground	96	85	11	*12*
On ground but adopted by females on wire	33	16	17	*51*
Abortions	7	7	—	—
Totals	237	140	97	*41*

[a] To weaning stage when most young were ear tagged and liberated.

TABLE 2.—MORTALITY AND SURVIVAL OF YOUNG HARES IN 1941 BY LITTER PERIODS.

Litter period	*Average young per litter*	*Litters*	*Young born*	*Died*	*Survived*	*Percentage survived*
1	2.6	43	113	86	27	*24*
2	3.6	24	86	48	38	*44*
3	2.9	9[a]	26	4	22	*85*
4	3.0	4[a]	12	2	10	*83*
Totals	2.9	80	237	140	97	*41*

[a] Marked reduction in number because most of original breeding stock liberated at this time.

ADOPTIONS

Under game farm conditions there would likely be many times when the caretaker would have orphaned hares. Considerable information on adoptions was obtained during 1941. The young females which gave birth to their leverets while on the ground were fre-

quently transferred to wire-bottomed pens with females having litters of similar age or size; in all, 33 such adoptions were made but 16 died. The 17 (51%) were liberated after they reached weaning age. One female that lost all her young, then successfully raised a litter of adopted hares of similar age. In only one or two instances did the foster mother harm the young. The main cause of death among the adopted leverets was coccidiosis, many having been exposed to infection before they were put up for adoption. The usual practice was to divide the young so that no foster mother would have to nurse litters larger than four or five and no ill effects were noted from this policy. Unnecessary adoption is not recommended, but the data show that there is a good chance of success when the occasion demands.

TOLERANCE BETWEEN SEXES

During the first two breeding seasons the hares were less restricted and there was very little fighting between the sexes. When the pens were much reduced in size (to $4 \times 4\frac{1}{2}$ ft.) for the 1941 season, the animals were more closely confined and a few losses from fighting were sustained. A pugnacious female occasionally would harass other females as well as the male, and a few males harassed timid females. If allowed to continue a few may persist in such fighting until the vanquished dies of wounds. The caretaker can usually detect such individuals and provide other arrangements for them before either of the animals has sustained fatal injuries. Ninety per cent or more of individuals, regardless of sex, can be expected to tolerate one another, even under the degree of confinement during this study.

Males showed no tendency to harm the young, even in close confinement. The only danger to the leverets was in trampling by either the male or female, particularly during the courtship chase which is not dispensed with even in such small quarters. It is best to insure that the hutch is placed in the center of the pen and that the young are safely within before the pair is mated. Frequently the male can be left in the female's pen for several days if she shows no tendency to fight him after copulation has taken place.

TIME TO MATE

In February 1941, numerous pairs were placed together in an attempt to obtain early production but the first three litters were not born until April 17 and 18, indicating that the females were bred on or about March 12. A week more elapsed before additional litters began to appear, after which new ones were found almost daily. Hence, in the latitude of Maine, little can be gained by uniting the males and females prior to the second week in March. Since it would be desirable, in a controlled rearing project, to observe all breedings and thereby know the probable dates of parturition for each female, it would be best to keep the sexes separated until March 20. Pairings then can be made, but unless copulation takes place within a short period the animals should again be separated and an immediate attempt made with another male. At least a week should elapse before a second attempt is made to mate a female with the former male. As noted previously (1942: 21), if a male has not reached complete potency,

his attempted copulation may result in pseudo-pregnancy in the female, causing a three week delay in the first litter, unless an immediate successful copulation is obtained by use of another male. Even though the females are not bred until the last week in March, it is still possible for them to produce four litters a season.

PEN CONSTRUCTION

The primary modification in pen structure made in 1941 from that of previous years (1942: 68) was to place wire bottoms of ½-inch mesh in a representative group of pens within the control unit in an attempt to reduce coccidiosis mortality. This mesh size proved adequate to permit elimination of the pellets. The pens were also reduced in size to 4×4½ feet by dividing each 4×18 foot pen into four units; this was done to learn whether such small enclosures would prove adequate for breeding and rearing. With all wire construction, it is apparent that small pens are necessary from an economical viewpoint. In addition to the wire bottoms, the lower six inches of the sides were basketed with ½-inch mesh wire to prevent newly born young from escaping. The pens as described closely resemble the type used by commercial rabbitries. A large vermin-proof enclosure can be constructed to surround the various pen units. Each unit within the enclosure can then be movable, if desired, rather than permanent as in this experiment. This would eliminate annual repair necessitated by winter frost upheavals. Litter trays also may be added to the pens, but they should be 12 inches or more below the wire bottoms rather than practically flush as so often the case in commercial hutches. This will eliminate a good deal of labor, as weekly or monthly cleanings can replace the daily routine.

A new type of self-cleaning hutch was designed for these pens, of wood construction and 12×24×8 inches in size with a tin hip roof. The floor was inserted with an opening 1-inch wide along one end and at sufficient slant so that the pellets would roll out and drop through the wire bottom of the pen. These hutches, as well as the smaller pens, proved very satisfactory and were utilized freely by both adults and young.

Mortality from coccidiosis was greatly reduced, and losses through trampling or overcrowding were negligible; the sexes bred as freely in these pens as in those of any other type.

COST

No cost analysis was made for the 1941 studies but nothing occurred to change the estimated rearing cost—to the age of liberation—of $1.25 to $1.50 for each hare as determined by operations in 1940 (1942: 85–88).

SUMMARY

1. The breeding potential for the snowshoe hare in captivity is 8.7 young per female per season, based upon the following data: (1) gestation period of 37 days; (2) rebreeding on day of parturition; (3) average litter of 2.9 young; (4) average of 3.0 litters per season per female.

2. Survival of pen-raised hares was 84 per cent during the last two breeding periods of 1941 by reducing the occurrence of coccidiosis through specially constructed rearing units.

3. The rearing of leverets by foster mothers proved successful.

4. Even under close confinement there is reasonable tolerance in this species between sexes and between individuals of the same sex.

5. Females should not be mated with males prior to March 20 if a grouping of litters and a knowledge of their probable birth dates are desired.

6. The type of pen which proved most successful closely resembled that used by commercial rabbitries.

7. The production cost—to age of liberation—is estimated to be from $1.25 to $1.50 per hare.

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THE ROOSEVELT ELK ON THE OLYMPIC PENINSULA, WASHINGTON

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The materials here reported are based upon a three year study (1935–38) of the Roosevelt elk (*Cervus canadensis roosevelti* Merriam) and its range on the Olympic Peninsula, Washington. There was need of reliable information on the number of animals, their seasonal distribution, the annual net increase, and the food resources of the range. The wintering areas on several elk ranges were being over-grazed, elk had died in considerable numbers, and crop damage was occurring in farming areas. Factual data on the life history and on the conditions of the elk and their range were needed to prepare a successful plan of management.

[1] Field work and original mimeographed report (1942?, 65 pp., 18 figs.) by Schwartz; condensed by Mitchell.

The principal objectives were to determine:

1. Range limits and number of elk in each herd.
2. Existing sex ratios, age composition of herds, annual net increase, and losses and their causes.
3. Proper utilization standards for key forage species.
4. Food habits of the elk, key forage species, and the proper stocking of each range.
5. Damage done by elk to the range and to soil resources.
6. Test the effectiveness of salting to obtain better distribution of the elk.

The range of this elk formerly extended throughout western Washington and Oregon and into California. With the development of logging industries

and settlement of the lowlands, the range has steadily receded until the animals are now restricted principally to the remote timbered and mountainous areas of western Washington and Oregon with a remnant in northwestern California. The largest population, between 6,000 and 7,000, occurs on the Olympic Peninsula. Elsewhere in Washington, elk are in scattered bands in several counties west of the Cascade Mountains.

In 1904 a bounty was offered for cougars and an intensified campaign was begun against predators. In 1905 the State Legislature made it unlawful to kill elk for a 10-year period; and in 1909, the Mt. Olympus National Monument was created to protect the elk. Signs of overpopulation and food shortage were evident by 1915. Important forage species had been seriously depleted and there was an extensive die-off during the winter of 1916-17. Since that time there have been periodic die-offs during severe winters.

This elk of the northwest coastal forest differs from the Rocky Mountain form (*C. c. nelsoni*) in being heavier, larger, with more massive but shorter antlers, and greater contrast between the light and dark portions of the coat. Deer referred to in this paper are the Columbian black-tailed deer (*Odocoileus columbianus*).

LIFE HISTORY

A mature bull elk in prime condition will weigh 700 to 1,000 pounds and an average cow in good shape between 400 and 700 pounds. Two adult females weighed 405 and 425 pounds, respectively; both were in poor condition, and unquestionably from 100 to 200 pounds under maximum weight. Typical measurements are given in Table 1.

TABLE 1.—AVERAGE MEASUREMENTS OF ROOSEVELT ELK, IN INCHES.

	Mature male, 5 years	Adult female, 4 years	Male fawn, 9 months	Female fawn, 3–5 days
Total length	98	92	72	37
Height at shoulder*	60	59	50	29
Length of hind foot	28	26.5	23.5	16.5
Length of ear	8	8	8	4.75
Length of tail	4	4	3	1.5
Antlers:				
Spread	40.5			
Circumference	11			
Length	44.5			
Number of points	6×6			

* Calves at 4 to 4½ months are 41 to 44 inches high at the shoulder.

MOLTING

The spring molt commences in late April and is completed in June. The physical condition of individual animals influences the time of molt. By late June all elk have acquired their summer coats, which are short, thin, and reddish brown. By September the autumn coat has replaced that of the summer season; the hair then is relatively long, thick and grayish brown, except for darker

portions on the head, mane, and legs. The coat continues to become denser and heavier and reaches full development by early winter. On the skin of a yearling female taken in February, the length of hair ranged from 2 inches on the sides and belly to 5 inches on the neck and shoulders. It is usually longer on mature bulls.

HERDING TENDENCIES

The cows and younger animals are gregarious and remain together in bands of varying size most of the year. During the calving season, pregnant cows tend to isolate themselves but since calves are dropped over a 30-day period, there is no time at which a band breaks up completely.

Elk are scattered in small bands during the spring and early summer. Just prior to the rut there is a definite tendency to congregate in large herds, often numbering several hundred, but when breeding starts the herds again break into smaller bands. Even during this period, bands of more than 50 have been observed. In the winter the small groups again combine to form larger herds.

Throughout the breeding season bulls are generally with the bands, but as winter advances many older males drift onto the higher benches and slopes or into the lower areas not regularly used by the herds. Bulls are often in groups, with up to 15 together. Where snow was fully 6 feet deep, 5 bulls were observed standing in a creek with water 1 to 2 feet preferring it to the snow. In February two old males were seen in 5 to 6 feet of snow. Evidence of a snow-bound bull in a limited area on top of a ridge showed the ground much trampled and the brush and trees severely browsed. This tendency to remain in high places during the winter may be responsible for considerable mortality among the bulls.

ANTLER DEVELOPMENT

Usually the antlers are shed between February 15 and April 15, and new growth starts soon after the old scars have healed. The earliest recorded shedding was on February 10, but adult bulls have been seen with antlers on April 19; most antlers are dropped during March. Studies of this process indicate some correlation between the condition and age of the animal and the dates of shedding.

New antlers grow quickly and by early June bulls may have 12 to 20 inches of growth with all points showing. By early August growth is complete and the velvet is shed by the first week in September. Spike bucks often retain the velvet throughout the year or until their antlers are shed.

The largest and most vigorous Olympic bulls have 6 points or more on each side, but most mature males grow 5-point sets. Thirteen sets of 5-point antlers measured during 1936 averaged a spread of 37.3 inches, a beam length of 38.2 inches, and circumference above the bur of 9.6 inches. The largest set recorded to date was 7×8 points with a spread of 52 inches. Further data are given in Table 2.

TABLE 2.—AVERAGE SPREAD OF 213 ELK ANTLERS MEASURED IN 1937 AND 1938.

Points per side	*Average spread, inches*	*Antler sets*
2	18.7	5
3	25.1	14
4	28.7	47
5	37.5	110
6	40.2	32
7	46.6	5

MATING AND BREEDING

Bugling starts shortly after the velvet has been shed. The earliest recorded date was August 24. It increases after September 1, reaches a peak between September 20 and October 1, diminishes throughout October, and by November is over except for an occasional call. The latest bugling was recorded on December 3, 1935.

Shortly after bugling starts, the herds break up and bulls collect their harems, which vary in size but usually contain 5 to 15 adult females. A band with a sex and age composition typical of most harems at this season contained a 5-point bull, 14 cows, and 3 calves. Usually some unattached bulls remain near a harem and, although the leader tries to keep them at a safe distance, he finds it difficult to do so. The leader sometimes is driven from the band by a challenger.

No fights between bulls were observed during the breeding season, but broken tines and evidence of pawing and skirmishing on the ground indicated a considerable amount of fighting. Several bulls were seen with broken main beams. Most fights consist of a few rushes and passes, with the larger and more powerful animal winning. No evidence of fatalities from elk fights was observed. There is friendly sparring of bulls after the breeding season and during the winter.

The only actual breeding record was observed by A. H. Lundgren; on September 18, 1938, he saw a bull make four covers of a young cow during a half-hour. Judging from the dates calves are dropped, most breeding takes place between September 15 and October 15.

CALVING

The average gestation period of elk is 249 to 262 days, or about 8½ months (Leopold, 1933). Development of the fetus appears to be gradual and uniform throughout this period. One fetus from a cow that died on January 20, 1938, was approximately 3½ months old and weighed 13.5 ounces. Another examined in late February 1936, in the fifth month of development, was one-third the size normally attained at birth.

The main calving period extends from May 15 to June 15, most of the calves being dropped from June 1 to 10. The earliest record date is May 14, and the latest July 10. No evidence of twin pregnancy was found.

At birth, elk calves are long-legged, ungainly creatures, covered with soft reddish-brown hair interspersed with numerous white spots on the back and sides (Pl. 14, B). The rump patch is rather indistinctly defined, but soon becomes prominent and light buff-brown in color. The nose and hoofs are black.

Elk calves are rather helpless during the first 3 or 4 days and, except for feeding periods, remain hidden beside big logs, under bushes, or at the bases of large trees. Their growth is rapid and when 10 to 14 days old they are amazingly swift and active, being able to scramble over logs 3 to 4 feet in diameter and to swim readily. The calves then are able to follow their mothers. They soon mingle with other calves and during the day will bed down together while the band is grazing. Often one or more cows, evidently with younger calves, remain in the vicinity acting as guards.

When 3 to 4 weeks old, elk calves eat

grass and other vegetation, and when 2 to 3 months old graze regularly with the adults (Pl. 14, C).

Weaning evidently is accomplished by early October; on December 16 a calf was attempting to nurse but was resisted by the cow. In September the calves shed their juvenile coats and acquire a winter pelage similar to the adults (Pl. 14, D)

MIGRATIONS AND MOVEMENTS

SEASONAL MIGRATIONS

Olympic elk are both resident and migratory, and there are gradations between the two habits. Resident elk live on the lower drainages and seldom move more than a few miles in any direction.

Migratory elk remain in the lowlands during the winter months, but closely follow the receding snows until they reach their summer ranges. Some make only short vertical migrations, ascending to nearby higher ridges for summer range.

In the autumn and early winter the down-valley movement starts with increasing snows and storms at higher elevations. Most of the elk return each year to the same wintering areas on their respective ranges. Shortage of forage does not seem to prompt a band to change range and they will starve to death when there is plenty of forage in the next drainage. Occasionally, intense hunting, a severe storm or some unusual circumstance will result in part of a herd drifting into another valley where they start another herd.

In February 1937 a rancher placed a bell on a weakened cow elk that he found. She recovered, rejoined a band in the locality, and by late May was working up-valley toward the head of the Quinault River. The course of her migrations and her location on certain dates are shown in Figure 1.

If the movements of this animal were normal, it appears that migratory elk return to the same locality to winter and they follow definite, well established routes of travel between the winter and summer ranges.

MOVEMENTS AND FEEDING

Daily movements are governed largely by feeding habits. In the winter the elk appear to have regular routes of travel in going to and from food and water. They usually feed in the bottoms from daylight until 9 or 10 A.M., then gradually work toward the benches and hillsides to bed down during mid-day. They commence to feed again at 4 or 5 P.M., working back toward the bottoms where they eat until after dark. On stormy and windy days they seek the shelter of heavily timbered areas. During the summer, elk will bed down on open river bars during the mid-day hours, apparently to avoid flies. However, they may feed at any time during daylight hours, even in summer. When most of the band is bedded down, during the middle of the day, a few usually will be foraging close by and it is seldom that all are down at one time. When the daylight hours are few and food is scarce, the feeding periods become longer, and under severe conditions the animals forage all day.

TAGGING STUDIES

Light metal ear tags, each bearing a serial number and instructions to return to the forest supervisor, were used in 1936 and 1937 when 16 calves

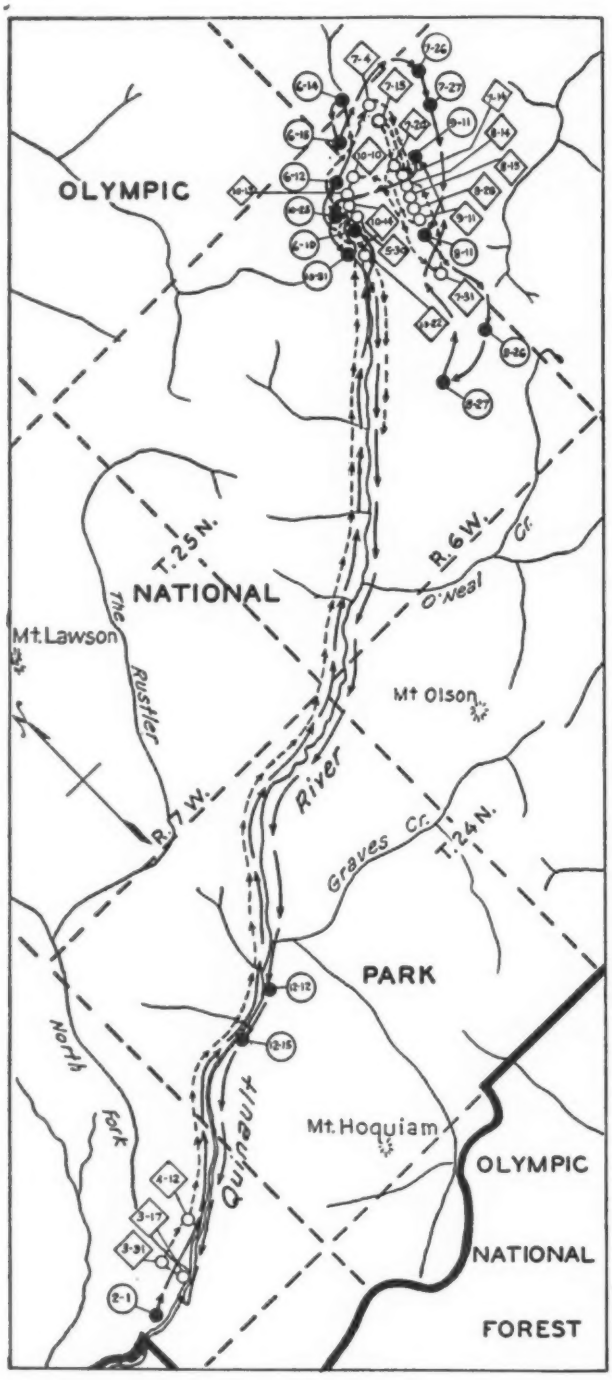

Fig. 1. Route (arrows) and location of belled cow elk. 1937: location, ●; route →: dates, 2-1 [=Feb. 1], etc. (in squares). 1938: location, ○; route, — — →; dates, 3–31, etc. (in circles).

were tagged. Tags of three were recovered by hunters in the season of 1937; two had been shot within two miles of where tagged, and the third about six miles away.

FEEDING HABITS

An important phase of the study was to determine the feeding habits on the seasonal ranges, particularly in winter. Elk eat a wide variety of plants, but depend chiefly upon a few common and abundant forms of browse, weeds, grasses, and ferns. Their use varies with season and locality.

Direct observation of feeding habits proved of little value when small herbaceous plants were being grazed. Competition between livestock and game is limited. Indirect observations were made by trailing bands to note the freshly grazed plants and by recording the utilization of various forage plants where evidence indicated elk had fed. This method proved most valuable. An analysis of stomach contents yielded considerable information on the proportions of plants taken, and served to check information by both direct and indirect observation (Table 4).

ACTIONS

Feeding elk move slowly in one general direction unless part of the band is bedded down, when the feeding individuals do not go far away. Normally an animal will alternate feeding along the ground and on higher clumps or browse. Usually the plant which is most palatable and abundant at the time receives the greatest use. The intensity with which elk feed over an area depends upon the season and the abundance of available forage. In winter they feed longer and more closely on individual clumps of browse or patches of vegetation.

Elk normally browse to a height of about 6 feet, although large bulls reach higher. When branches at heights of more than 7 feet have been browsed, it indicates they were eaten when weighed down by snow. The Olympic elk both browse and graze. During the winter, when all herbaceous forms are buried by deep snow, they browse exclusively, but with the appearance of early spring plants 75 to 90 per cent of the food is of weeds and grasses. As the season advances, there is again an increased use of browse. New leaves of huckleberry, salmonberry, and vine maple are taken in large amounts and about balance the diet between browse and herbaceous forms. More grazing than browsing is done on the summer and autumn range.

Elk are more damaging to a range than deer, and sometimes even more so than domestic stock. Their habit of concentrating is responsible for trampling and packing of the soil on both summer and winter ranges.

PLANT UTILIZATION

The parts of plants used vary with the seasons. During spring and summer fresh, succulent leaves, stems, and tender twigs are mostly taken. In the late autumn and winter twigs, both dry and evergreen leaves, bark, and sometimes rotten wood fibers are eaten. Sporophores of certain fungi are also eaten. More than 100 different plants are taken by the Roosevelt elk, but those shown in Table 3 are the most important species.

Forage conditions and other factors

vary so widely over the entire Olympic Peninsula and between different drainages that no attempt has been made to evaluate the approximate percentages of each important plant utilized.

one of the first to show evidence of overuse; nevertheless, it survives the effects of overbrowsing most successfully and when given adequate protection makes rapid recovery.

TABLE 3.—PLANTS EATEN BY ROOSEVELT ELK.[a]

Name	Parts eaten	Seasons used	Distribution	Life Zones	Abundance	Palatability	Relative importance
TREES AND SHRUBS							
Vine maple (*Acer circinatum*)	L-T-B-RW	Y	G	T-C	A	E	H
Sitka alder (*Alunus sinuata*)	L-T	Su	G	C-H	A	F	M
Willow (*Salix scouleriana*)	L-T-B	*W*-Sp	G	T	C	C	M
Willow (*Salix sitchensis*)	L-T-B	*W*-Sp	G	T-C	C	G	M
Western hemlock (*Tsuga heterophylla*)	L-T-RW	F-W	G	T-C	C	G	H
Salal (*Gaultheria shallon*)	L	F-*W*-Sp	G	T-C	A	F	M
Salmonberry (*Rubus spectabilis*)	L-T	Y	G	T-C	C	G	H
Black huckleberry (*Vaccinium membranaceum*)	L-T	Sp-*Su*-F	G	C	A	G	M
Blue huckleberry (*Vaccinium ovalifolium*)	L-T	Y	G	T-C	A	G	M
Red huckleberry (*Vaccinium parvifolium*)	L-T	F-W-Sp	G	T-C	A	G	M
SEDGES, FERNS, ETC.							
Sedge (*Carex ablata*)	L-H	*Su*-F	G	H-A	A	G	H
Sedge (*Carex leptopoda*)	L	Sp	G	T	A	G	M
Spring beauty (*Claytonia sibirica*)	L-Fl	*Sp*-Su-F	G	T	A	E	M
Youth-on-age (*Leptaxis menziesii*)	L	F-W-*Sp*	G	T	C	G	M
Wood-sorrel (*Oxalis oregana*)	L	*Sp*-Su	W	T-C	A	G	M
Sword fern (*Polystichum munitum*)	Fr	Y	G	T-C	A	F	M
Deer fern (*Struthiopteris spicant*)	Fr	F-*W*-Sp	G	T	C	G	M
Threeleaf coolwort (*Tiarella trifoliata*)	L-Fl	F-W-*Sp*	W	T-C	A	G	M
Grey moss (*Usnea barbata*)	All	*W*-Sp	G	C-H	C	G	M

[a] 18 other shrubs and 17 other plants used are of low importance.
Key: Parts eaten: L., Leaves; T, twigs or tips; B, bark; RW, rotton wood; Fl, flowers, S, stems; Fr, fronds; H, heads.
Seasons used: F, fall; W, winter; Sp, spring; Su, summer; Y, yearlong.
Distribution: E, eastern; W, western; G, general.
Life Zones: T, transition; C, Canadian; H, Hudsonian; A, Arctic Alpine.
Abundance: A, abundant; C, common; R, rare.
Palatability: E, excellent; G, good; F, fair; P, poor.
Relative importance: H, high; M, medium; L, low.

Vine maple (*Acer circinatum*) is a key species on most important winter ranges of the Peninsula. It is a good indicator of range conditions, being

At least five species of huckleberry (*Vaccinium*) are browsed. All except evergreen huckleberry (*V. ovatum*), are important sources of food on both

winter and summer ranges and furnish much of the elk diet. They are about as palatable as vine maple, and one or more species are browsed during every month.

Salmonberry (*Rubus spectabilis*) occurs commonly along the lower stream courses, in swamps, and on mountain slopes up to about 4,000 feet. It does not receive the heavy winter use generally considered. From spring until late autumn, the palatability is high and salmonberry is also an indicator of range saturation and over utilization.

The important evergreens used include the following:

Western hemlock (*Tsuga heterophylla*) is the principal conifer browsed. Observations and stomach analyses indicate that elk depend to a considerable degree upon the leaves and slender twigs during the winter and, to a lesser extent, during spring and autumn. It is less palatable than western red cedar, but of more importance because of its greater abundance and availability.

Western red cedar (*Thuja plicata*) is very palatable to elk and fallen limbs or branches within grazing reach are usually trimmed closely. Reproduction is sometimes killed on the more heavily populated drainages. It ranks only fair in relative importance because much of its growth is above the reach of elk.

Douglas fir (*Pseudotsuga taxifolia*) is widely distributed throughout the Peninsula; most of the foliage is above browsing reach and reproduction is scarce except in forest openings and on logged-off lands. Wherever trees are windthrown or branches are broken off, they are eagerly sought by elk and all edible portions are utilized. Storms and heavy snows usually occur with enough frequency during the winter to make the supply of fallen trees and limbs a fairly dependable food source.

Sitka spruce (*Picea sitchensis*) is common only in the Transition and lower Canadian zones of the west-side drainages. Despite the sharp-pointed needles, it is eaten in moderate amounts during the winter even on slightly utilized ranges. The foliage from limbs broken off near the tops of trees seems to be preferred. Spruce reproduction is far less palatable and is taken only when other foods are scarce.

Lichens (*Usnea barbata, U. plicata,* and *Ramalina reticulata*) are common on the trunks and limbs of trees and referred to as "grey moss." During the winter, especially at higher elevations, they are important in the diet and are taken from as far up as the animals can reach. On the high ridges at this season, the elk apparently depend largely upon lichens and the browse from broken limbs of fir and hemlock.

A fairly large number of grasses (Gramineae) occur on the Olympic Peninsula, but few are abundant. The wide, low valleys in the western half of the peninsula and the subalpine meadows of the higher portions of the range support the most extensive stands. Even through these areas, however, the usually associated species of sedges are much more abundant.

STOMACH ANALYSES

Of the 23 stomach samples analyzed, 14 were from animals killed during the autumn hunting season and 9 from animals that died during the winter. Besides the plants listed in Table 4, 15 others were identified only by traces. Not enough samples were included to

TABLE 4.—ANALYSES OF ELK STOMACH SAMPLES.

Species	Occurrence	Percentage of total volume
AUTUMN MONTHS (14 stomachs)		
Deer fern (*Struthiopteris spicant*)	13	9.4
Black cottonwood (*Populus trichocarpa*)	7	9.0
Salal (*Gaultheria shallon*)	5	8.9
Grass	13	5.6
Salmonberry (*Rubus spectabilis*)	10	4.1
Threeleaf coolwort (*Tiarella trifoliata*)	11	3.0
Western hemlock (*Tsuga heterophylla*)	14	2.7
Vine maple (*Acer circinatum*)	10	2.5
Lady fern (*Athyrium filix-femina*)	7	2.5
Moss (*Hylocomium* sp.)	12	1.7
Western red cedar (*Thuja plicata*)	5	1.0
Sitka spruce (*Picea sitchensis*)	5	1.0
Wood-sorrel (*Oxalis oregana*)	5	1.0
Huckleberry (*Vaccinium* sp.)	2	1.0
Blackberry (*Rubus macropetalus*)	2	1.0
Brake fern (*Peteridium aqualinum*)	2	1.0
Fungus (Polyporacae)	1	1.0
Bigleaf maple (*Acer macrophyllum*)	1	1.0
Alder (*Alnus rubra*)	3	1.0
WINTER MONTHS (9 stomachs)		
Western hemlock (*Tsuga heterophylla*)	9	13.1
Sword fern (*Polystichum munitum*)	8	9.2
Sitka spruce (*Picea stichensis*)	5	7.3
Vine maple (*Acer circinatum*)	4	5.4
Black cottonwood (*Populus trichocarpa*)	3	5.4
Salal (*Gaultheria shallon*)	5	5.0
Sedge (*Carex* sp.)	4	4.6
Douglas fir (*Pseudotsuga taxifolia*)	5	3.4
Red cedar (*Thuja plicata*)	4	3.4
Longleaf hollygrape (*Odostemon nervosus*)	3	3.2
Grass	4	3.2
Elk fern (*Struthiopteris spicant*)	2	1.8
Blackberry (*Rubus macropetalus*)	2	1.2
Coolworth (*Tiarella trifoliata*)	2	1.0
Youth-on-age (*Leptaxis menziesii*)	1	1.0
Huckleberry (*Vaccinium* sp.)	2	1.0
Mitrewort (*Mitella ovalis*)	2	1.0
Moss (*Hylocomium* sp.)	1	1.0
Chickweed (*Stellaria washingtoniana*)	1	tr.
Unidentified	9	29.6

furnish an accurate picture of the autumn food. Huckleberry, for instance, is considered one of the most important autumn browse plants, but was recorded from only two stomachs and composed less than 1 per cent of the total volume. Vine maple, on the other hand, according to field observations is lightly browsed during the autumn, but appears as one of the more important. If a greater amount of the unidentified material, largely of woody fibers, could have been accurately determined, different proportions of these species probably would have been obtained.

Most of the winter samples were from animals that had died of malnutrition and disease on overgrazed ranges; the proportions and species probably would

TABLE 5.—WEIGHTS OF ELK PAUNCHES. (in pounds)

No.	Sex	Date	Paunch[a] and contents	Contents only
155	Ad. ♀	Feb. 12	98	—
166	Ad. ♀	Mar. 31	85	—
167	Ad. ♀	Mar. 31	60	—
179	Ad. ♂	Oct. 26	89	71
180	Ad. ♂	Oct. 26	84	66
181	Ad. ♂	Oct. 27	79	63
183	Ad. ♂	Oct. 26	83	67
186	Ad. ♂	Oct. 28	—	51
187	Ad. ♂	Nov. 3	—	78
188	Spike ♂	Nov. 4	—	44

[a] Average net weight of the paunch (rumen), 16 to 19 pounds.

have been different had they lived under better conditions. It is significant that 27 per cent of the identified material was of coniferous browse.

The weights of paunch contents are summarized in Table 5.

MINERAL REQUIREMENTS

No natural licks or springs, attractive to elk or deer, were found on any western drainages, but on the east side of the peninsula a number of licks are used by both. Salt placed at six places on the west side was not used by either species and apparently the coastal elk have little desire or need for salt (Murie, 1935).

RANGES

WINTER RANGE

Each of the 16 major drainages of the Olympic Peninsula supporting elk includes well defined winter ranges. These occupy the valleys and lower slopes, from a few hundred feet to about 2,000 feet above sea level. The climate of all, except the extreme northeastern section, is excessively rainy during the autumn, winter, and spring; on the south and west sides the annual rainfall often exceeds 150 inches. Part of the winter precipitation is as snow, from about 6 inches on the lower west side to more than 4 feet on the upper limits of the occupied ranges. Most of the snow is heavy and wet, subject to frequent thawing and freezing, with resulting crusts that often seriously handicap deer and elk in their search for food. Heavy snow, however, frequently weighs down or breaks off branches which would otherwise be unavailable as forage. In general the greatest use on the normal winter range occurs from November until June.

The logged-off lands also are used in winter and make excellent elk range because they support a much larger growth of browse, weeds, and grasses as compared with timbered areas. For about 10 years after logging, or until grown up with conifer reproduction, these areas furnish abundant natural forage. Logged areas that contain small islands of standing timber at frequent intervals to provide the necessary cover are more favored.

Since some areas are occupied by resident elk throughout the year, the winter ranges have been classified on the basis of either yearlong use or winter use only (Fig. 2).

WEST-SIDE DRAINAGES

The river systems draining westerly into the Pacific Ocean are the Soleduck, Calawah, Bogachiel, Hoh, Clearwater, Queets, and Quinault. They are low, wide valleys, usually heavily timbered, and provide extensive wintering areas with variable amounts of the more important forage plants. The upper limits of winter range in most of them are at elevations of 1,500 to 2,000 feet.

Because of the mild and wet climate, the plant growth is more profuse and forage productivity is greater there than on other parts of the Peninsula. Of the total elk population on the Olympic Peninsula, 85 per cent is on these ranges. Hence, problems of overpopulation and range depletion are most common in these watersheds, although some are underpopulated.

Prior to 1936, overbrowsing and range depletion had progressed farther on parts of the Hoh River than on any other Olympic range, and a distinct elk line was evident on shrubs and trees

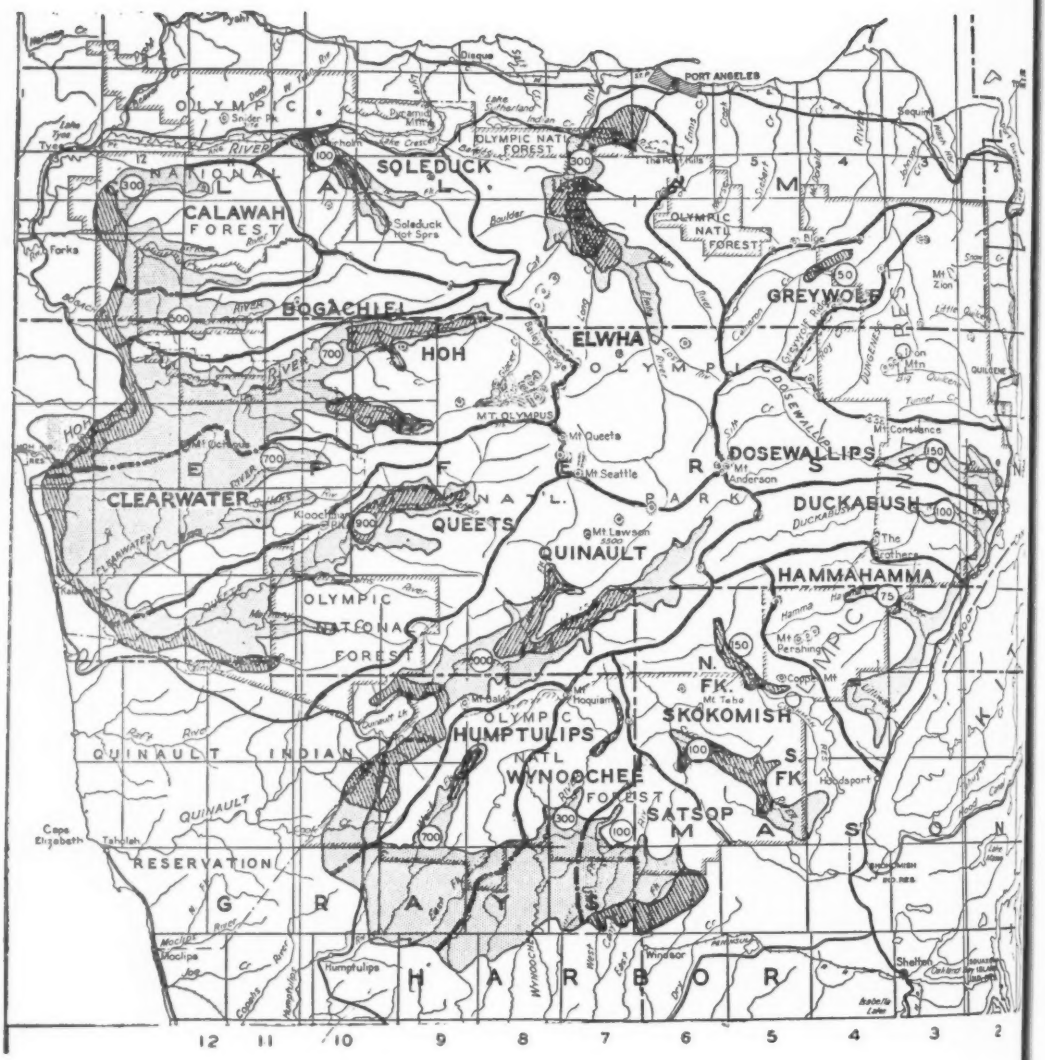

Fig. 2. Winter range of Roosevelt elk on Olympic Peninsula in 1938. \\\\, used mainly during winter; ////, winter range overpopulated; circled figures, estimates of elk present. Total estimated population, 6,225 elk.

throughout the area. Estimates of the degree of seasonal utilization on overbrowsed portions of the Hoh drainage by percentage of annual growth were as follows:

WINTER, twigs only

	Vine maple	Huckleberry
1936	90	80
1937	75	70
1938	40	50

SPRING AND SUMMER, twigs and leaves

	Vine maple	Huckleberry
1936	60	70
1937	50	60
1938	—	—

From the forks of the Hoh River to the ocean the range is understocked and could support several hundred more elk.

Several other drainages are relatively overgrazed, but the intensity of use varies. Overbrowsing is much in evidence, but localized in creek bottoms. On the Queets drainage the percentage use was:

WINTER, twigs only

	Vine maple	Huckleberry
1936	—	—
1937	80–100	70–90

SPRING AND SUMMER, twigs and leaves

	Vine maple	Huckleberry
1936	50–60	40–60
1937	50–60	40–60

Because of the lack of uniform use of the concentration areas in the Quinault watershed, it has been difficult to determine average utilization of the more important browse species, but the percentage estimates were:

WINTER, twigs only

	Vine Maple	Huckle-berry	Salmon-berry
1936	70	55	70
1937	75	55	70
1938	65	50	65

SPRING AND SUMMER, twigs and leaves

	Vine Maple	Huckle-berry	Salmon-berry
1936	50	40	45
1937	50	40	45
1938	—	—	—

The west side is typical elk range. Intensive hunting on the overstocked areas should tend to reduce numbers and force the elk to spread to the less used ranges.

SOUTH-SIDE DRAINAGES

The river valleys on the south side are similar in climate, vegetation, and topography to the larger west-side drainages. From the national forest boundary north they comprise low, heavily timbered ridges and valleys. Below the boundary much of the land has been logged and on many parts there has been considerable regrowth of important food plants.

The valleys support typical growths of vine maple, salmonberry, ferns, huckleberry, wood-sorrel, and other plants. The benches are likewise well vegetated.

The principal watersheds in the eastern part of the Olympics all drain into Hood Canal. On the Canal side the mountains attain high elevations a short distance inland and the short rivers flow through steep narrow canyons; bottom lands and benches are limited. The per-acre carrying capacity is estimated at 50 to 75 per cent less than on the west side. On the lower parts of the drainages there are extensive cut-over lands which produce considerable forage and compare favorably with other peninsula ranges in that regard.

The annual precipitation is less than that along the west side, but the snowfall is usually greater on the winter elk ranges, mainly because most of them lie at higher elevations where seasonal temperatures are slightly lower.

The principal browse plants are

Ceanothus, *Arctostaphylos*, and *Cornus*, found exclusively on the east side; otherwise, the variety of forage species is approximately the same as that on the west- and south-side ranges.

The drier east-side ranges are more suitable for deer and, except for the South Fork of Skokomish River, management should favor deer over elk.

NORTH-SIDE DRAINAGES

This area is characterized by narrow deep valleys of moderate gradient, containing limited bottom lands and narrow benches which merge into steep mountain slopes. The surrounding ridges and peaks are 5,000 to 6,500 feet in elevation. The snow averages about 2 feet at 2,000 feet elevation, but consistently deeper above. Elk range up to 2,500 feet, and a few go even higher.

There is a great variety of plants; the understory browse and herbaceous species, comprising the winter elk diet, correspond with those of the drier Hood Canal drainages. There are limited stands of vine maple along the lower portions of the river. Grey moss is common and is taken as high as the elk can reach. Low plants such as salal, Oregon or holly grape, and ferns are available virtually all winter. When snow covers the low browse, the elk depend upon fallen limbs of Douglas fir and cedar together with the moss on them or that blown off the trees.

Overbrowsing of huckleberry, salmonberry and vine maple is evident on much of the winter range. Red huckleberry has suffered most, showing from 60 to 90 per cent utilization; it is the best indicator of present conditions and trends. Salmonberry is not abundant. Salal, Oregon grape, deer fern, and sword fern, show moderately heavy use, and locally salal and deer fern are overutilized.

Game on this area has been under complete protection since October 1935, when much of the range was set aside as the Elwha Game Refuge. Deer have been responsible for most of the overgrazing. Both elk and deer are too numerous and should be reduced. The Elwha is one of the best deer ranges on the peninsula and reductions should favor the deer.

SUMMER RANGE

The summer range includes the upper timbered valleys and ridges and the higher, open subalpine areas (Pl. 14, A). The extreme northeastern part of the Forest is probably the only area without elk in summer. The greatest concentrations are near the headwaters of the Hoh, Elwha, Queets, and Quinault drainages (Pl. 14, E).

The tendency of elk to remain long on favorite feeding and bedding grounds has resulted in overbrowsing on certain areas; in every instance there are adjacent areas with adequate forage. Overutilization appears to have been underway for sometime, but through a period of years a gradual shifting of the elk concentration areas may occur, thus permitting a slow recovery of some heavily grazed places.

The most heavily browsed plant species were mountain ash, 80–90 per cent; salmonberry, 75–100 per cent; and spirea and black huckleberry, 50–90 per cent. The greatest damage occurs in the order listed. Herbaceous plants such as valerian, caltha, and arnica, likewise were closely grazed.

Roosevelt elk in the Olympic Peninsula, Washington. *A*. Principal summer range on low timbered ridges of Queets and Quinault drainages (photo near Kimta Peak, Sept. 1937). *B*. Calf 2 to 3 days old when tagged on East Fork, Quinnault River, June 1936; killed about one mile away and tag recovered, October, 1937. *C*. Calf, 2½–3 months old, adult winter coat replacing juvenile pelage, September 1938. *D*. Calf, about 4 months old, juvenile pelage replaced, October 1938. *E*. Small band on typical summer range, Elwha River, May 1938.

FORAGE STUDIES

Intensive studies of range conditions on the overbrowsed portions of certain valleys were made. A number of enclosures were built to protect typical overgrazed portions from further use, and sample plots established, both inside and outside these areas. Takedown enclosures to control grazing use also were provided.

ENCLOSURES

Twelve fenced enclosures, from 45×45 to 100×200 feet, were established on representative portions of the overgrazed ranges each containing typical samples of one or more key forage species. Studies were made on the rate of recovery and other vegetative changes of the protected plants. In addition there were controlled clipping experiments simulating various degrees of grazing use. The plant growth was measured on sample plots inside each enclosure. There was an average gain of 18 per cent in the density of ground cover. The composition of each area by species indicated an increase in browse of 18.6 per cent, and corresponding decrease in weeds and grasses of 10 and 8.6 per cent, respectively.

Of particular interest was the seemingly rapid recovery of salmonberry in some enclosures. Except for Enclosures 3 and 4 on the Quinault, none on either the Hoh or Quinault in 1935 contained more than a trace of this plant, but in 1938 all had 1 to 4 per cent of salmonberry. Judging from the then rapid rate of recovery, much more would be present during the next few years. An outstanding example occurred in Enclosure 3, where in 1935 only 10 per cent of the vegetation was salmonberry but in 1938, it comprised fully 50 per cent. The west quarter of the plot was densely covered by salmonberry 5 to 8 feet in height, whereas outside the plot it was only 6 to 24 inches in height.

TABLE 6.—DENSITY OF GROUND COVER AND PLANT COMPOSITION WITHIN ENCLOSURES; ESTABLISHED 1935, RETYPED IN 1938.

Enclosure	Year	Density of ground cover	Percentage composition		
			Grass	Weeds	Browse
Hoh					
No. 1	1935	7	6	60	34
	1938	8	tr.	37	63
No. 2	1935	7	25	45	30
	1938	9	5	44	51
No. 3	1935	4	11	50	9
	1938	7	1	83	16
Quinault					
No. 1	1935	5	10	65	25
	1938	7	4	59	37
No. 2	1935	3	—	60	40
	1938	5	—	48	52
No. 3	1935	6	8	37	55
	1938	8	—	30	70
No. 4	1935	7	10	30	60
	1938	8	1	5	94

SAMPLE PLOTS

In order to measure the vegetative

trends on overgrazed ranges, 92 permanent sample plots were established, each 10 feet square. These were of sufficient size so that the browse vegetation within could be measured and charted to scale. Nineteen of the plots were located within the enclosures to determine plant recovery under complete protection. The remainder were staked out at various places on the typical ranges. The number of sample plots on each drainage according to key plant species were as follows:

	Vine maple	*Huckleberry*	*Salmonberry*	*Totals*
Hoh.....	20	20	3	43
Queets...	7	6	3	16
Quinault.	10	11	12	33
Totals.	37	37	18	92

Thirty of the plots established in 1935 were remeasured in 1938. There was a marked recovery in growth and vigor of the plants on protected and grazed plots.

UTILIZATION STUDIES

Effort was made to determine the extent to which the principal forage plants may be browsed and still maintain normal growth. Three methods of study were used: (1) actual utilization of the plants on the range, (2) clipping studies, and (3) analysis of regulated browsing by use take-down enclosures. Most information was obtained by the first method. This originally was intended to supplement the other two, but was largely the basis for conclusions because sufficient time had not elapsed at the close of the project, to draw definite conclusions from the others.

Repeated observations on the effects of actual grazing use of important forage species and of ranges with various degrees of annual utilization were made to determine the maximum use different species could stand and still maintain normal vigor and growth. The following tentative standards were established for the Olympic ranges:

	Percentage use
Vine maple	40–60
Huckleberry	50–70
Salmonberry	40–60

POPULATION STUDIES

ESTIMATED ELK POPULATIONS

Organized counts of elk were made on the Hoh, Queets, and Quinault drainages during the winters of 1935 and 1936, and on the Elwha Valley in 1938. Because of the generally mild conditions during both winters, the elk were rather scattered and results were disappointing. The estimated population and the carrying capacity by ranges for 1938 were as follows:

Drainage	*Population*	*Capacity*
Soleduck	100	100
Calawah	300	400
Bogachiel	500	700
Clearwater	700	700
Hoh[a]	700	400
Queets[a]	900	600
Quinault[a]	1000	700
Humptulips[b]	700	800
Wynoochee	300	300
Satsop	100	100
South Fork Skokomish[c]	100	100
North Fork Skokomish[d]	150	50
Hamma Hamma	75	150
Duckabush[d]	100	100
Dosewallips[d]	150	150
Greywolf[d]	50	50
Elwha[d]	300	100
Total	6225	5500

[a] Overgrazed.
[b] Poor distribution.
[c] Best for elk.
[d] Best for deer.

AGE CLASSES AND SEX RATIOS

Counts of all elk on 5 different drainages during the study totaled 7,049 definitely identified by sex and age (Table 7).

Determination of the percentage of

yearlings of both sexes is made by doubling that for spikes. This would give 8 per cent as the yearling population and would subsequently reduce the cow population by that amount. The number of breeding cows is figured by eliminating the aged females and 2-year olds. About 40 per cent of an elk population may be estimated as breeding females (Rush, 1932), but our study indicates a slightly higher percentage among the Olympic elk. Counts of all cows and calves seen during July and August in 1936, 1937, and 1938 totaled 419 cows and 255 calves. This would indicate that about 61 per cent of all cows had calves; allowing for reasonable mortality among the calf drop during May and June, it would seem safe to place the percentage even higher. Assuming that 66 per cent of all elk are adult females (not including yearlings) and 65 per cent of them produce calves, the breeding cows would average 43 per cent in a typical herd.

Comparing the monthly percentages for calves shows a marked decrease in this group. (After May, all remaining members of this group were classed as yearlings.) Apparently there is heavy mortality within this age class. The losses are from malnutrition and parasitism during the winter, but losses from predators and accidents are also of importance, particularly during the summer and autumn. Of 94 calves examined from the fetal stage to about 10 months, 39 per cent were males, a ratio of 64 males to 100 females.

The most accurate tally on the proportion of bulls in any herd was on the Humptulips where they represented 16 per cent of the total herd (Table 8).

TABLE 7.—SEX AND AGE CLASSES OF ELK, BY DRAINAGE AREAS.

Drainage	Bulls		Spikes		Cows		Calves	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Elwha	23	*6.3*	5	*1.4*	284	*77.5*	54	*14.8*
Hoh	123	*4.3*	121	*4.2*	2,115	*73.7*	515	*17.9*
Quinault	180	*6.6*	124	*4.5*	1,829	*67.2*	588	*21.2*
Queets	68	*7.3*	17	*1.8*	645	*69.8*	193	*20.9*
Humtulips	27	*16.4*	12	*7.3*	91	*54.5*	35	*21.2*
Totals and averages	421	*6*	279	*4*	4,964	*70*	1,385	*20*

There had been no hunting in this area since 1933.

The adult bulls are estimated to constitute 10 to 20 per cent of the total population. If 15 per cent is considered normal and breeding cows average 43 per cent, the ratio would be one bull per 2.8 breeding females. In actual breeding, however, the ratio is wider because probably not over 30 per cent of adult bulls participate, the remainder being immature and overaged.

LOSSES

During the winter and spring of 1936, 1937, and 1938, 112 elk were found in either dead or dying condition. From the frequency of dead animals found on typical areas of heavy elk concentration it is estimated that at least 400 succumbed during 1937 on the Hoh, Clearwater, Queets, and Quinault drainages.

During mild winters, two-thirds of

all those that die are adults, mostly aged, but in severe winters (e.g., 1937) deaths among calves almost equal those of adults. Animals 2 to 6 years or older survive a severe winter better than other age groups. The winter losses were as follows:

Year	*1936*	*1937*	*1938*
Total carcasses	25	66	21
Adults, percentage	*85*	*52*	*67*
Calves, percentage	*15*	*48*	*33*

TABLE 8.—SEX AND AGE CLASSES OF ELK OBSERVED ON THE HUMPTULIPS DRAINAGE, 1936–38.

	Bulls		Spikes		Cows		Calves	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
January	63	*4.2*	60	*4.0*	1,141	*75.8*	241	*16.0*
February	83	*4.4*	84	*4.5*	1,366	*72.5*	350	*18.6*
March	46	*6.0*	41	*5.4*	566	*74.4*	108	*14.2*
April	35	*9.0*	20	*5.1*	295	*76.0*	38	*9.8*
May	13	*7.5*	3	*1.7*	140	*80.9*	17	*9.9*
June	12	*5.2*	2	*.8*	176	*75.9*	42	*18.1*
July	39	*6.9*	4	*.7*	319	*56.6*	202	*35.8*
August	8	*4.9*	1	*.6*	100	*61.7*	53	*32.7*
September	33	*14.3*	12	*5.1*	128	*55.4*	58	*25.1*
October	21	*10.0*	6	*2.9*	147	*70.3*	35	*16.7*
November	23	*7.6*	14	*4.6*	185	*61.0*	81	*26.7*
December	45	*7.0*	32	*5.0*	401	*62.8*	160	*25.1*

MALNUTRITION AND DISEASE

Losses among elk on the west side drainages are both direct and indirect results of overpopulation. Malnutrition induced by eating coarse woody browse and coniferous growth has been the principal contributing factor. Postmortem examinations of animals dying during the winter all disclosed characteristic symptoms of malnutrition, the most pronounced being emaciation; the watery, gelatinous appearance of fatty tissue beneath the skin; and much coarse and relatively unpalatable forage in the paunch. The quality rather than quantity of food taken was responsible for the poorly nourished condition.

The coarse material produces lesions in the mouth from wounds by the sharp, woody portions. According to Murie (1935), such lesions frequently are invaded by *Bacillus necrophorus*, the causative organism of necrotic stomatitis, and the most important bacterial disease of deer and elk in the Olympic region. In all 32 autopsies were made besides partial examinations of incomplete or putrefied carcasses. The parasites and necrotic lesions found in the 32 autopsies were:

	Number	*Percentage*
Lungworms (*Dictyocaulus viviparus*)	23	*72*
Ticks (*Dermacentor albipictus*)	13	*47*
Lice (*Bovicola americanum*)	14	*44*
Tapeworms (*Thysanosoma actinioides*)	7	*22*
Intestinal worms (*Oesophagostomun venulosum* and *Trichuris* sp.)	5	*15*
Sarcosporidia (*Sarcocystis*)	4	*12*
Bot fly larva (*Cephenomyia*)	2	*6*
Lesions in mouth	5	*15*

Lungworms (*Dictyocaulus viviparus*) were widespread and important para-

sites. Of all elk examined during the winter and spring months 72 per cent showed infestations from light to heavy. In some, the worms completely occluded many large air passages. As the summer advances and feed becomes more abundant, elk gain rapidly in condition and seem largely to rid themselves of these worms, but many remain lightly infested throughout the summer since 5 of 13 examined during the hunting seasons in October of 1936 and 1937 contained a few (O'Roke, 1936).

A liver fluke (*Fascioloides magna*) is the only trematode thus far observed in elk and deer of the Olympic Peninsula; records of its occurrence are limited to certain west-side drainages but it probably is rather widespread. Practically all fluke infestations were found during the autumn, when the degree of infection varies by drainage basins. The greatest concentration was found on the South Fork of the Hoh, where 81 per cent of the elk killed contain flukes. None was reported from the Quinault, where most other parasites were found.

Sarcosporidia (*Sarcocystis* sp.) appears to be common; about 40 per cent of the hearts examined from elk shot by hunters showed this parasite on the inner lining and throughout the muscle tissue. It has also been observed in the tongue and cheek muscles.

A tapeworm (*Thysanosoma actinioides*) is one of the more common internal parasites; heaviest infestations are usually during the winter and spring, but some have been observed even in autumn.

Intestinal worms (*Oesophagostomum venulosum* and *Trichuris* sp.) appear to be common in the intestinal tracts, and in somewhat greater abundance and frequency in calves than in adults.

The moose tick (*Dermacentor albipictus*) is the most widely distributed and commonest parasites on Olympic elk. It apparently occurs on every watershed, but the heaviest infestations were found on the Elwha.

The biting louse (*Bovicola americanum*) was first described in 1935 and is the only kind heretofore found on Olympic elk.

Bot fly larvae (*Cephenomyia* sp.) apparently do not occur in elk with the same frequency as in deer. They were found in only two, both calves, and neither contained a heavy infestation.

A few cases were diagnosed as calf diphtheria (necrotic stomatitis) in postmortem examinations. This disease is present among elk on the crowded ranges and probably is a contributing cause to some deaths. Murie (1935) concluded that it was a major cause of elk loss on the Peninsula. About 15 per cent of the animals autopsied showed one or more necrotic lesions on the jaws or other membraneous portions of the mouth. In addition, several adults had molars missing and the tooth sockets entirely healed over.

An attempt was made during the hunting season of 1937 to determine whether Bang's disease was present but no evidence was found. There may be some relationship between barrenness and conditions of malnutrition and parasitism, but no definite determinations were possible.

CALF LOSSES

Each year during calving season a few young one or more days old were found dead. The evidence indicated all deaths

resulted either from general weakness or pneumonia.

PREDATORY ANIMALS

Four principal predators occur on the Olympic Peninsula, the mountain lion or cougar (*Felis concolor oregonensis*), bobcat (*Lynx rufus fasciatus*), coyote (*Canis latrans lestes*), and bear (*Euarctos americanus altifrontalis*). The cougar is the most destructive to deer and elk because it preys on both young and adult animals throughout the year. Bobcats, coyotes, and bears are largely seasonal in their killing and confine themselves chiefly to fawns and younger animals.

COUGAR

The role of large cats in elk and deer mortality is imperfectly known. The materials collected were from ranges where elk are abundant and it would appear that cougars have definite preference for deer. This assumption is upheld by many experienced cougar hunters and by residents of the Peninsula. There is abundant evidence that cougars can kill elk without difficulty. In February 1936 a cougar killed an adult elk. A few hours later it was tracked down and shot, proving to be a yearling that weighed only 76 pounds. The elk, apparently healthy, was judged to weight about 600 pounds. The evidence in the snow indicated there had been little struggle between the two.

The food items in 28 cougar scats from the Olympic National Forest, were as follows:

	Number	*Percentage*
Washington varying hare (*Lepus washingtoni*)	11	*32*
Deer (*Odocoileus columbianus*)	8	*23*
Elk (*Cervus canadensis roosevelti*)	3	*9*
Pine squirrel (*Sciurus douglasii*)	2	*6*
Mountain beaver (*Aplodontia rufa*)	2	*6*
White-footed mouse (*Peromyscus*)	2	*6*
Wood rat (*Neotoma*)	2	*6*
Meadow mouse (*Microtus*)	1	*3*
Flying squirrel (*Glaucomys sabrinus*)	1	*3*
Bones	1	*3*
Hair	1	*3*

BOBCATS

Bobcats are fairly numerous throughout the Olympic Peninsula. To big game their destructiveness is limited mainly to deer, and of these young fawns, although they occasionally kill yearlings and even adults during the winter.

Analyses of 6 stomachs and 99 scats from the Hoh, Queets, Quinault, and Elwha drainages in 1935–38 showed the following:

	Number	*Percentage*
Washington varying hare (*Lepus washingtoni*)	65	*43.9*
Pine squirrel (*Sciurus douglasii*)	27	*18.2*
Deer (*Odocoileus columbianus*)	8	*5.4*
Wood rat (*Neotoma* sp.)	7	*4.7*
Salmon	8	*5.4*
Meadow mouse (*Microtus sp.*)	6	*4.0*
Flying squirrel (*Glaucomys sabrinus*)	7	*4.7*
Jumping mouse (*Zapus*)	2	*1.3*
White-footed mouse (*Peromyscus*)	3	*2.0*
Mountain beaver (*Aplodontia rufa*)	2	*1.3*
Western mole (*Scapanus*)	1	*.7*
Grouse (*Dendragapus obscurus*)	1	*.7*
Winter wren (*Nannus hiemalis pacificus*)	2	*1.3*
Grass (Poaceae)	2	*1.3*
Feather quills	4	*2.7*
Bones	1	*.7*
Fir needles	1	*.7*
Fish bones	1	*.7*
Total	148	

COYOTES

Coyotes inhabit the lower, logged-off lands on the south, east, and north sides of the Olympic Peninsula. They seem to be entirely absent from the heavily timbered valleys of the west-side drainages, and only on the more open northeast portions of the range are they found at higher altitudes. (6,000 to 7,000 feet). Little is known of the present trend of the population; the local consensus is that the animals are increasing slowly, but are not yet abundant.

BLACK BEAR

The Olympic black bear ranges throughout the Peninsula and has been condemned by local residents as most destructive of elk fawns. Many people advocate drastic reduction in its numbers and some favor complete elimination. Bears do prey on deer and elk fawns, but seemingly the habit is developed in certain individuals and not among bears as a group, and observations during the summers of 1936, 1937, and 1938 substantiate this belief. All bear scats found were examined for evidence of elk and deer; of more than 100 samples, 8 per cent contained evidence that fawns had been part of the diet.

The causes of mortality among elk on winter ranges during 1936–38 were: disease and malnutrition, 21; predators, 10; accidents, 8; undetermined, 73; total, 112.

ELK DAMAGE

Damage to crops and property is frequent in parts of the Olympic Peninsula where agricultural areas are within or near the winter range of elk or deer. In the Hoh, Clearwater, Queets, Quinault, and Elwha districts, farmers suffer periodic losses from elk. Hay, both in fields and in stacks, is eaten or trampled, garden crops are grazed and trampled, and stampeding herds destroy fences. Damage during the spring and early summer largely by resident bands. The Washington State Game Department has attempted to relieve the situation by delegating men to patrol farms and frighten away the elk. Flares, bombs, and scarecrows have been used with varying success, but none proved entirely satisfactory. Trapping elk for transplanting has been tried to remove the elk from the vicinity of ranches. In the winter of 1938, a corral trap was built on the Elwha and baited with hay, but only eight animals were trapped because of the mild winter and abundance of natural forage. Trapping as a solution to elk damage is of limited value because of the expense. The only practical method of protecting both the farmers and the elk is to construct elk-proof fences.

HUNTING SEASON

During this study, elk hunting was permitted on the Peninsula each year in October. A total of 1,187 elk were taken, 268 during the first year, 811 the second, and 108 the third (Tables 9, 10). The territory opened to hunting differed somewhat each season. The limit for 1936 restricted each hunter to one male with branched antlers. In 1937 one of either sex and any age was allowed. The 1938 season was restricted to a small area and the bag limit allowed only male elk, including spike bucks.

The Hoh is the most accessible to

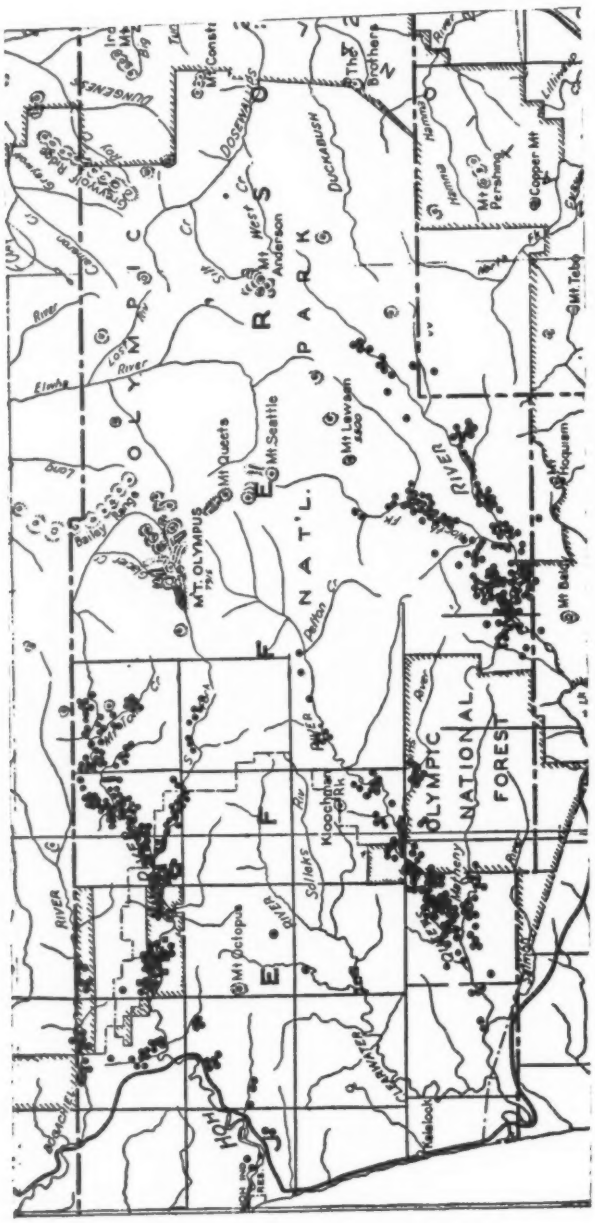

Fig. 3. Kills of elk (●) in Olympic Peninsula, season of 1937.

TABLE 9.—KILL OF ELK BY DRAINAGE BASINS.

Hunting season	1936		1937		1938	
Drainage	Number	Percentage	Number	Percentage	Number	Percentage
Bogachiel	10	*4*	21	*3*	4	*4*
Hoh	115	*42*	374	*43*	45	*42*
Clearwater	41	*16*	118	*15*	21	*19*
Queets	49	*18*	133	*16*	22	*20*
Quinault	50	*19*	184	*22*	14	*13*
Coastal drainages	3	*1*	8	*1*	2	*2*
Totals	268		811		108	

TABLE 10.—PERCENTAGE COMPOSITION OF ELK KILL IN 1937 HUNTING SEASON.

Drainage	Number	Percentage			
		Cows	Calves	Spikes	Bulls
Bogachiel	21	*34*	*5*	*19*	*42*
Hoh	347	*64*	*13*	*10*	*13*
Clearwater	118	*64*	*11*	*9*	*16*
Queets	133	*51*	*14*	*13*	*22*
Quinault	184	*47*	*18*	*11*	*24*
Coastal drainages	8	*38*	—	*24*	*38*
Total	811	*57*	*13*	*11*	*19*

TABLE 11.—ANTLER DATA FROM MALE ELK KILLED DURING HUNTING SEASONS.

Drainage	Total for each drainage			Percentage								
				4 points or less			5 points			6 points or over		
	1936	1937	1938	1936	1937	1938	1936	1937	1938	1936	1937	1938
Hoh	109	36	36	*28.4*	*33.3*	*41.7*	*44.0*	*47.2*	*47.2*	*27.5*	*19.4*	*11.1*
Queets	39	22	19	*10.2*	*22.6*	*15.8*	*66.6*	*54.6*	*57.8*	*23.0*	*22.7*	*26.4*
Clearwater	31	21	16	*35.5*	*38.0*	*37.5*	*38.7*	*47.6*	*62.5*	*25.8*	*14.2*	—
Quinault	34	35	12	*5.8*	*31.4*	*16.7*	*47.0*	*54.3*	*58.3*	*47.0*	*14.3*	*25.0*
Bogachiel	9	8	3	*22.2*	*12.5*	*67.0*	*44.4*	*50.0*	*33.0*	*33.3*	*37.5*	—
Soleduck	7	—	—	—	—	—	*57.1*	—	—	*42.8*	—	—
Coastal drainages	1	3	2	—	—	*50.0*	—	*66.6*	—	*100.0*	*33.3*	*50.0*
Totals Averages	230	125	88	*21.7*	*29.6*	*32.0*	*47.8*	*51.2*	*52.3*	*30.4*	*19.2*	*14.8*

hunters and the elk on that range are widely distributed. Most of the hunting was done in the river bottoms and lower slopes of drainages penetrated by roads; hence the less heavily stocked portion of the valleys, mainly with resident bands of elk, were hunted most heavily. Migratory elk still on the summer range were less disturbed (Fig. 3).

The hunting seasons were intended to relieve the overpopulated ranges, but that objective was only partially real-

ized because much of those ranges are inaccessible. Only on parts of the Hoh (North Fork) and on the Quinault were reductions enough to effect improvement in forage conditions by the summer of 1938.

ANTLER CLASSES

Data for the three seasons show that the percentage of 5-point bulls killed was approximately the same each year, but the take of bulls with antlers of 6 points or more decreased, from 30 per cent in 1936 to 15 per cent in 1938 (Table 11). There was a corresponding increase in the numbers of younger males with antlers of 4 points or less. The decrease in old and increase in younger animals indicated that the adult bull population was being depleted.

SUMMARY

A cooperative study of Roosevelt elk on the Olympic Peninsula, Washington, was made by the U. S. Forest Service, U. S. Fish and Wildlife Service, and Washington State Game Department, to obtain information for a comprehensive elk management plan in respect to overgrazed elk ranges on the Hoh, Queets, and Quinault rivers. Between 6,000 and 7,000 live on the Peninsula.

The Roosevelt elk is somewhat heavier and larger than the Rocky Mountain form, but in most respects the life histories of the two are the same.

Breeding occurs between September 15 and October 15, harems are of 5 to 15 adult females, and calves are born from about May 15 to June 15.

The elk usually return to the same winter range each season, even when the ranges are depleted. They browse during the winter, but in spring, summer, and autumn, grazing and browsing are about equal. Over 100 different species of plants are eaten, but 25 form the main diet. The principal browse species are vine maple, huckleberry and salmonberry, but western hemlock, western red cedar, Douglas fir, and Sitka spruce, are much used.

Ranges on the west side support more elk than the drier east-side drainages. The winter ranges are a few hundred feet to about 2,000 feet above sea level, and logged-off lands are important wintering grounds.

Hunting and heavy winter losses have effected some improvement in forage conditions. The Hood Canal drainages and the Elwha, on the north, are better for deer than for elk. The Elwha ranges are depleted because of an overabundance of deer.

Plants protected within fenced experimental enclosures showed marked recovery in growth and vigor. The permissible degree of utilization was determined to be from 40 to 60 per cent for vine maple, 50 to 70 per cent for huckleberry, and 40 to 60 per cent for salmonberry.

Of 7,049 animals identified by sex and age there were 70 per cent adult cows, 20 per cent calves, 6 per cent adult bulls, and 4 per cent spike bulls; 43 per cent of all adult cows were breeding. There is heavy mortality among calves. Bulls constitute from 10 to 20 per cent of the total elk population.

In all, 112 elk were found dead during the study, 21 from malnutrition and disease, 10 were cougar kills, and 8 accidents. The heaviest losses were in 1937, when more than 400 died of malnutrition and disease on the Hoh, Clear-

water, Queets and Quinault drainages. During that winter, calf losses equaled those of all other age classes combined. The excessive losses on the west-side drainages resulted from malnutrition. Overpopulation is a factor in increasing the incidence of parasitic infection among the elk. Findings from 32 post-mortem examinations showed the usual infection by sarcosporidia, lungworms, tapeworms, intestinal worms, bot flies, ticks, and lice.

Cougar, bobcat, coyote, and bear are the principal predators in the Olympics, and cougar are the most destructive to elk and deer. Other small mammals, in addition to deer and elk, are included in the cougar diet. Analyses of 99 bobcat scats indicate the food of the animal to be largely neutral in character. About 8 per cent of a few bear scats contained remains of elk fawns.

A total of 1,187 elk were killed during the three seasons, 42 per cent from the Hoh drainage. Hunting helped to relieve the pressure on some ranges.

The number of bulls with antlers of 6 or more points decreased from 30 per cent in 1936 to 15 per cent in 1939.

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SYMPTOMS OF MALNUTRITION IN DEER

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To a casual observer, a deer may look strong and healthy after having spent the winter on an overbrowsed range or on a range that has been covered with deep snow for many weeks. But is it? Deer food on the winter range at its best does not put fat on a deer. The diet available, even in moderate winters, is at the most merely a subsistence diet. If deep snow covers the greater portion of the choice deer browse or if the range has been overutilized, thereby forcing the deer to take more and more of the forage of low palatability to keep its stomach full, we are then headed for malnutrition in the deer herd and the eventual death of the deer.

During the summer and early autumn months deer build up reserves of fat distributed throughout various parts of the body. This fat is stored during the plant growing season when good nutritious food plants are abundant. If you kill a deer in the autumn, when many states have an open season, this is about the picture you will find. You will be impressed, when you dress the deer, by the handfuls of fat inside the body—fat that can be stripped from the intestines. Also there will be fat around the kidneys and a spot of

fat on the heart. In skinning the deer you will notice layers of fat over the saddle and the hips, on the outside of the ribs, on the brisket, and on other parts of the body. The hide is strong and does not tear. You remark the fine condition of the animal. When you cut your steaks, the bone marrow is solid and rich creamy-white in color.

Then winter hits with all its fury. There are no green forbs or green leaves on deciduous trees and shrubs for browse. The diet of the deer undergoes a great change, because the list of palatable foods has been reduced to a limited few that may have to be pawed out of the snow. Our deer is now on the winter range, and though many of the foods he eats are low in nutritional value, still he eats and his body demands additional good food if he is to exist. Hence he starts to draw on the reserves of fat that were stored in his body during the summer and early autumn to make up for what the available food lacks.

First the fat over the rump and the saddle disappears, and then gradually the fat that lies between the hide and body cavity is absorbed. On close observation you will notice that the deer does not look so sleek and well rounded as he did during hunting season. His hide is loose and reminds one of a man with an oversized suit of clothing. The next step of fat absorption occurs within the body cavity proper. That around the kidneys and on the intestines disappears, and the last to be absorbed within the body cavity is the spot of fat on the heart. A really critical stage in the life of our deer now is approaching. He still can jump and run, and he looks bright and snappy, although his coat is looser and rougher. You still think he is in good condition, but the truth is he has only one more reserve of fat to use. Remember those steaks you cut and the nice creamy-white color the bone marrow had? That rich creamy-white color of the bone marrow was due to fat cells. Now the deer begins to absorb those fat cells. Gradually the marrow turns red and finally becomes jelly-like, which means the fat cells have been absorbed.

The deer is still apparently full of life. He can jump and run, but he is only living on borrowed time, and in a few days when you jump him from his bed he springs up and starts off but soon staggers and falls, he gets up and tries again only to stagger and fall again, this time to stay down. The next day or so you find his body and make a post-mortem. First you run your hand down his back bone. It feels like the teeth on a buzz saw. The hide tears easily when skinning and there is no fat outside the body cavity. Next you open the body cavity. The lungs are in a healthy condition, and the stomach is full, but all the fat from the intestines, that over the kidneys, and the spot on the heart, have been absorbed. Next you take a rock, a hatchet, or a saw and break or saw the tibia to find that the bone marrow is red and jelly-like. The tibia is the best bone to test, as this condition begins to show there before it shows in the metatarsal bone; but in advanced stages of malnutrition the same condition shows in other bones.

A study of malnutrition in the northern area of the Black Hills of South Dakota was possible during the winter of 1943–44 because extremely deep

snow covered most of the winter range. Normally southern exposures are snow-covered for only short periods after storms, but on November 6, 1943, there were 14 inches of snow on the level, and all through December 1943 and January 1944 from 12 to 24 inches of snow covered the area. From January 27 to the first of April 1944, 30 to 50 inches of snow lay over the range. Of course, this extremely deep snow covered the better foods such as bearberry, Oregon grape, and ground juniper.

The deer were in good condition on January 13, at the close of the antlerless deer season. Signs of malnutrition began to show up after the deer had spent six weeks on the winter range, and appeared first in the fawns. By February 13 all the fat between the hide and body had been absorbed. By the last of February the fat on the inside of the body cavity had disappeared. By March 15 evidence of extreme malnutrition was found, and during the rest of March and all of April malnutrition was the chief cause of death in a good many deer. Of the 185 dead deer checked, omitting 35 adults legally killed during antlerless deer season, January 7–13, 1944, 95 (63+%) were fawns and 55 (36+%) were adults. In a few cases the factors contributing to the deaths were predators or minor infestations of internal and external parasites, such as nose bot (*Cephenomyia*) and winter tick (*Dermacenter albipictus*). The greatest loss occurred in April after the snow had gone, when green grass and forbs were available. All the deer then found dead had full stomachs. Tests and observations were conducted personally on 150 whitetail deer (*Odocoileus virginianus macrourus*) and 35 mule deer (*Odocoileus hemionus*) and enough of the stomachs were analyzed to get a good cross section of the food being used during this period of extremely severe conditions. Losses on the ranges of concentrated wintering ran from 21 deer per section in one unit to 40 per section in another. Observations were not casual but were conducted in the field at least three days of each week during the first four months of 1944. Stomach analyses were made by Ralph R. Hill, U. S. Forest Service, Halsey, Nebraska, who has been analyzing Black Hills deer stomachs since 1940.

TABLE 1.—STOMACH ANALYSES OF WHITETAIL DEER DYING DURING THE WINTER. (Percentages)

Plants	*Normal year (1942) 15 specimens*	*Abnormal year (1944) 50 specimens*
Bearberry (*Arctosphylos uva-ursi*)	32	17
Oregon grape (*Odostemon respens*)	17	11
Grass (mostly *Poa*)	13	5
Snowberry (*Symphoricarpos albus*)	8	—
Forbs (unclassified)	6	9
Ground Juniper (*Juniperus communis*)	5	8
Serviceberry (*Amelanchier*)	5	3
White birch (*Betula papyrifera*)	4	—
Ponderosa pine (*Pinus ponderosa*)	3	23
Oak (*Quercus macrocarpa*)	1	2
Bittersweet	2	2
Chokecherry (*Prunus melanocarpa*)	1	8
Everlasting (*Antennaria*)	1	—
Unidentified browse	—	3
Yucca	—	2
Prickly pear	—	2
Sumac (*Rhus cismontana*)	—	1
Miscellaneous	2	4

In the first four months of 1942, a normal year, stomach analyses of white-

tail deer showed that 32 per cent bearberry was used as against 17 per cent in the abnormal year of 1944; that 17 per cent Oregon grape was used in 1942 against 11 per cent in 1944; and that 3 per cent pine was used as compared with 23 per cent in 1944. (Table 1 shows further differences in diet.) Only the stomach analyses for whitetail deer are shown as there were not enough mule deer stomachs obtained in 1942 to make a fair comparison with those obtained in 1944. Two factors probably governed the differences in diet of the deer during the two years shown on the figures. One is that the heavy snow covered the more palatable food and they could not obtain as much as they would normally. The other is that the heavy snow drove the deer off their natural winter range onto farm lands in the foothills, which lack in the more palatable foods. Table 2 shows the rapid advance of malnutrition. The change from good to poor physical condition takes place within six weeks. All those in poor condition showed definite signs of malnutrition.

TABLE 2.—PHYSICAL CONDITION OF 150 WHITETAIL AND 35 MULE DEER CHECKED DURING THE FIRST FOUR MONTHS OF 1944.

Month	*Condition*[a]	*Number*
January	Good	34
January	Fair	7
January	Poor	2
February	Good	—
February	Fair	1
February	Poor	10
March	Good	—
March	Fair	1
March	Poor	46
April	Good	—
April	Fair	—
April	Poor	84

[a] Good, fat in all parts of body.
Fair, fat only in body cavity.
Poor, no fat in body; bone marrow red and jelly-like.

KNOWLEDGE, ABILITIES AND TECHNIQUES NEEDED BY A WILDLIFE MANAGER

REPORT OF THE COMMITTEE ON PROFESSIONAL STANDARDS

I. RECOGNITION OF WILDLIFE FORMS

1. *Animals.* He must know the characteristics, habits and life histories of the common birds and mammals, and be able to recognize them and their work in the field. He should know the same for lower animals, except life histories. He should be able to recognize fragments of members of major animal groups, and prepare evidence for files.

2. *Plants.* He must know the common plants well, and usually be able to determine the identity of unknowns whether or not they are in flower or fruit. He should be able to recognize fragments of common plants and prepare evidence for files.

II. ECOLOGICAL KNOWLEDGE

1. *Types.* He must be able to recognize ecological types of vegetation.

2. *Coactions.* He must have at least a rudimentary understanding of the influence of animals upon one another, the influence of animals upon plants, and the effects of kind and arrangement of vegetation upon the animal inhabitants of a locality.

3. *Topography and climate.* He should understand the significance of site, the influence of soil, moisture, exposure, and climate upon the kinds of plants and animals that can live in certain places.

4. *Techniques of land use.* He must have some knowledge of the effects of logging, burning woodland and prairies, draining marshes and swamps, flooding, cultivation, and the various other activities of man upon the plants and animals in a locality, for these are the tools of the wildlife manager. He must also understand the effects of man's carelessness and the destructive forces of nature: wind, water, fire, insects, fungi, etc. He must be familiar with the techniques of handling lands where wildlife is produced, whether the chief use be for agriculture, forestry, recreation, mining, or other uses.

III. SPECIAL TECHNIQUES

1. *Mapping.* He must deal with lands. Therefore it is necessary that he be familiar with the system of land subdivision in the locality where he will work. He should be able to locate boundaries and tie in his activities with these boundaries or with other known reference points. In forested or wild country he should be able to run lines and map physical features with facility and reasonable accuracy. In farming country the running of lines may be less important, but mapping is no less essential. He must be able to make vegetative type maps in the field with facility and accuracy.

2. *Sampling.* He must have an elementary understanding of the principles of sampling, because many of the facts on which he will base his management will be obtained by sampling methods.

3. *Tracking.* He must be able to track common animals by footprints

and other signs, and read the stories of action by various signs along a trail with a high degree of accuracy in interpretation.

4. *Harvesting surplus.* He must be familiar with various hunting and trapping equipment, methods of use, handling and preparing of harvested game and fur, and of marketing prices and methods. He should be an able hunter and trapper.

IV. ADMINISTRATION

1. *Laws.* He must understand the machinery, both national and local, by which wildlife and other natural resources are administered. He must know the laws applied in wildlife administration, why they were adopted, and how effective they have been.

2. *Economics.* He should have an understanding of the law of supply and demand, have an understanding of values, and a knowledge of costs, so that he will appreciate the financial limitations that must limit his activities.

V. PUBLIC RELATIONS

1. *Contacts.* He must have an appreciation of human elements that may limit his activities, and understand how to use public speaking and the written word in gaining public confidence. He must be able to manage assistants.

The above outline is based primarily on material supplied by Samuel A. Graham with minor additions from other members. It may be interpreted locally, regionally, or nationally. The best man has widest knowledge and abilities. This report was submitted in mimeograph form to each member present at the annual meeting of the Wildlife Society in Chicago, on April 24, 1944. Additions, corrections and amendments were solicited with the understanding it would be proposed for publication later. A few changes were made in the original form.

Committee on Professional Standards
LEO K. COUCH
GUSTAV A. SWANSON
ALLEN M. PEARSON
GEORGE H. KELKER
SAMUEL A. GRAHAM
GEORGE O. HENDRICKSON, Chairman

Device for opening pheasant bands.

Device for opening pheasant bands.

BRIEFER ARTICLES

RAPID METHOD FOR OPENING AND ARRANGING PHEASANT BANDS

To overcome some of the difficulties encountered while banding large numbers of pheasants, the method here described was developed under Massachusetts Federal Aid in Wildlife Restoration Project 3-R-1 in 1943. Its use permitted greater efficiency in banding the birds and simplified the keeping of records. Slight modifications of equipment would permit the application of this method to the banding of species requiring bands of sizes other than those used on pheasants.

The bands are opened by a special tool (Pl. 15) devised by Fred W. Wood, Culturist of the Massachusetts Division of Fisheries and Game. This is made from a 16-inch strap hinge (*b*) of which one leaf is fastened to a wooden block (*a*) 1×6×18 inches. A piece of metal ¼×1×1¼ inches (*c*) is welded to each leaf, at the point of connection, in such a manner that, as the hinge is spread flat on the block, these pieces are $\frac{5}{16}$ inch apart at the top but flush at the bottom. The inner surface of each piece terminates in a small tongue (*d*) to fit inside the band. A 5-inch segment of ordinary door spring (*e*) is connected from the end of the fixed hinge leaf to the base of the tongue on the opposite upright metal piece. Tension on the spring raises the unattached leaf until the two inner surfaces of the uprights join.

The device is operated by placing a band over the two tongues on the uprights and pressing down the end of the loose hinge, thereby spreading the tongues and opening the band. A small adjustable wood block (*f*) beneath the movable hinge leaf determines the degree to which a band is opened. A practiced operator can open and arrange 800 bands an hour.

The pheasant bands were arranged on ½-inch wood dowels, in numerical order as opened. A wood block 30×6 inches was equipped with holes to hold dowels, strung with bands, while the actual banding was being done. Bands could be removed from the dowels in numerical order as needed for use. —WILLET N. WANDELL, *Division of Wildlife Research and Management, Department of Conservation, Boston, Massachusetts.*

ASPERGILLOSIS IN WOOD DUCKS

During September 1943, some 2,000 to 3,000 wood ducks (*Aix sponsa*) congregated in the flooded Langellier Levee and Drainage District, four miles south of Havana, Illinois. Most of them were feeding on spoiled corn around a crib partially destroyed by flood waters late in May 1943.

The flood waters gradually receded and by mid-September were only 24 inches deep in the farm yard where the crib was located. Leo Borgelt, of the U. S. Fish and Wildlife Service, reported many sick and dead wood ducks in the area, and on September 18 we visited the area with him. There were four dead and 15 sick wood ducks close to the crib, which contained several thousand bushels of moldy corn. On a section of land surrounding the crib there were about 25 dead ducks along banks of drainage ditches, and of 775 living wood ducks seen, 75 were incapacitated to some degree.

Many of the sick ducks walked with effort and could not fly. Some were able to fly only a few yards and others flew as though suffering from shot injuries. The individuals suffering most severely breathed with difficulty, their mandibles opened and closed convulsively, and their tails jerked spasmodically.

Four of the freshest of the dead birds were opened, and found to have a fungus covering the anterior organs. The specimens were taken to Dr. Robert Graham, Professor of Animal Pathology and Hygiene, University of Illinois, who identified the fungus as an *Aspergillus;* in turn he sent samples to Dr. L. R. Tehon, Botanist of the Illinois Natural History Survey, who carried the molds

through the necessary cultures on standard identification media and determined them as *Aspergillus fumigatus* Fres.

Ten apparently healthy wood ducks flew from around the corn crib at our first visit, but no other living ducks were seen there until dark when 800 to 1,000 flew in from various parts of the drainage district. The moldy corn did not seem to be unpalatable to them, for they consumed it eagerly.

No actual counts were made in the ensuing days, but we estimated that, up to October 1, 60 additional wood duck carcasses were found around the crib; how many more died at a distance we do not know. About 10 per cent of the 500 to 1,500 ducks congregating each morning and evening on the moldy corn appeared to be affected. This situation prevailed until October 3, when continued recession of the water and cool weather resulted in the exodus of most of the wood ducks.

Undoubtedly the feeding ducks distributed the mold by shattering the spores, then breathing the spore-laden air, and soon developed the condition known as aspergillosis. The disease appeared locally among those ducks that fed on the moldy corn, but it affected so many as to assume epizootic proportions.

Most published reports of aspergillosis among wild birds are of isolated cases, but Davis and McClung (1940) recorded the disease as epizootic among herring gulls in Massachusetts. Phillips and Lincoln (1930) cite two cases among waterfowl, and Zeliff (1943) records the infection in the lungs and air sacs of a mallard. There are four references to this mold in gulls, one in a snowy owl, and a few in other species of birds. Shillinger (1942) states that it "produces fatal infections of wild waterfowl as well as quail on game farms and appears to be more highly pathogenic for these birds than for domestic chickens."

Fox (1923) writes that "under the names of Aspergillosis and brooder pneumonia, the infection with *Aspergillus fumigatus*, *A. glaucus* and others is well known to breeders of chickens, ducks and ostriches. . . . Judging from our experience it would seem probable that the aspergillus can, under conditions not fully explained, cause inflammation of the avian air sac and tubercles in viscera, in the absence of other evident causes of illness and death."

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—FRANK C. BELLROSE, JR., and HAROLD C. HANSON, *Illinois Natural History Survey*, and P. D. BEAMER, *Department of Animal Pathology and Hygiene, University of Illinois, Urbana, Illinois.*

SEX RATIO AND WEIGHTS OF VERMONT BOBCATS IN AUTUMN AND WINTER[1]

In 1935 Dr. Russell P. Hunter, then Director of the Vermont Fish and Game Service, began collecting stomachs of the bobcat (*Lynx rufus rufus*) for food habits analysis. Bounties have been paid continually on the species since 1909, and many of the animals brought to game wardens for bounty payment since 1935 have been examined, weighed, and measured. Most of these were taken from October to March. Hamilton (Journ. Mammalogy, **21**: 218, 1940) recorded the weights of 74 Vermont bobcats, the average being

[1] Contribution from Pittman-Robertson Project 1-R, Vermont Wildlife Resources Survey, 1944.

15 pounds 4 ounces, and the maximum 36 pounds.

The weights of 376 Vermont bobcats taken from 1935 to 1945, including Hamilton's data are summarized in Table 1. Practically all were weighed, except a few estimated by game wardens examining the cats. The 101 males averaged 19.4 pounds but the 250 females only 14.5 pounds. Seton (Lives of Game Animals, 1(1): 1929) quoted Bachman as noting that females are smaller than males, but no other data on dimorphism appears available in the literature. Our maximum record was a 36 pound male, and the largest female weighed 35 pounds. The smallest taken, a female, weighed only 2.75 pounds. Eastman (A History of Vermont . . . Brattleboro, Holbrook and Fessendon, 1828) recorded a "wild cat" taken in Vermont which weighed 57 pounds; it probably was a lynx. Possibly three age classes are present in our sample. Hamilton believed that there were three classes in his sample of 74 cats, both from skull features and weights.

Among the 351 animals of which the sex was known there were 101 males and 250 females, a sex ratio of 40 males per 100 females. There seem to be no data available in the literature for comparison with these figures. Seton believed that the species is monagamous. Possibly the method of taking the cats has influenced the sex ratio reported, although the specimens presented for bounty have been taken in various ways, trapping, shooting, and accidental killing being the most usual.—LEONARD E. FOOTE, *Vermont Fish and Game Service, Montpelier, Vermont.*

TABLE 1.—WEIGHTS AND SEX OF AUTUMN AND WINTER VERMONT BOBCATS, 1935–45.

Weight, Pounds	*Sex*		*Unknown*	*Totals*
	Males	*Females*		
0– 2.9		1		1
3.0– 5.9	4	8		12
6.0– 8.9	7	30	2	39
9.0–11.9	8	54	6	68
12.0–14.9	10	56	4	70
15.0–17.9	21	44	8	73
18.0–20.9	14	26	3	43
21.0–23.9	10	12		22
24.0–26.9	6	7	1	14
27.0–29.9	3	4		7
30.0–32.9	9	7	1	17
33.0–35.9	8	1		9
36.0–38.9	1			1
Totals	101	250	25	376
Average weights, pounds	19.4	14.5		15.9

POCKET GOPHER FOOD CACHES IN CENTRAL UTAH

During the late summer of 1942, the writer unearthed five food caches of pocket gophers (*Thomomys talpoides moorei*) in widely scattered places on the Manti National Forest east of Ephraim, Utah, at elevations of 9,500 to 10,000 feet. Digging out runways there in search of storehouses involved many hours of labor; in many places it was doubly difficult because the shallow topsoil is underlain with varying quantities of limestone shale, which can be dug through only with a pick and crowbar. At one spot I worked a day and a half without finding the food cache, although the nest material and the gopher were taken.

Of ten attempts to locate food storehouses only five yielded food caches, although the nest material usually was found. The data on the caches, with the kinds, and green weights of vegetation were as follows:

No. 1. Three storehouses. September 9, 1942.

Tuber starwort (*Stellaria jamesiana*)	256 grams
Common dandelion (*Taraxacum officinale*)	352 grams
Dogtooth violet (*Erythronium* spp.)	3 bulbs
Unidentified seeds	few
Grass crowns	few

No. 2. One storehouse. September 21, 1942; 8 inches below surface.

Dandelion roots (*Taraxacum officinale*)	330 grams
Lanceleaf springbeauty bulbs (*Claytonia lanceolata*)	146 grams

No. 3. Two storehouses. September 28, 1942; 2 and 8 inches below surface, respectively.

Dandelion roots (*Taraxacum officinale*)	292 grams

No. 4. Two storehouses. September 29, 1942; both 6 inches below surface.

Dandelion roots (*Taraxacum officinale*)	16 grams

Dogtooth violet (*Erythronium* spp.) 53 grams
Tuber starwort (*Stellaria jamesiana*) 95 grams

No. 5. One large storehouse and a small one in nest cavity, at 2 and 12 inches below surface.

Dandelion roots (*Taraxacum officinale*) 358 grams

The above were the items actually stored by the gophers, and do not indicate what other foodstuffs may have been taken above ground or what other rooty materials were consumed underground.

On June 13, 1944, Paul Hansen of the same station, found another cache in a snowbank on Becks Ridge (elevation 10,000 feet) that contained:

Dandelion roots, 396 (320 grams);
Erythronium bulb, 1;
Erythronium shoots, 3.

On June 21, he found another cache inside of an earthen core which had evidently been placed in a snow tunnel and later came to rest on the ground when the snow melted. One section of this core, about 2 feet long, was filled with sprouting viola seed. Another section, about 4 to 5 feet long, was filled with the same kind of seed but unsprouted. There was just enough clay on the outside to cement the materials into a core.

TABLE 1.—SUMMARY OF THE CACHES.
(Weights in grams)

No.	*Dandelion roots*	*Tuber starwort*	*Dogtooth violet bulbs*	*Lanceleaf springbeauty bulbs*	*Totals*
1	352	256	3		611
2	330			146	476
3	292				292
4	16	95	53		164
5	358				358
Totals	1,348	351	56	146	1,901
Percentages	*71*	*18*	*3.4*	*7.6*	

An interesting sidelight on gopher habits was the finding of three caches made in snowbanks during the winter.

On May 1, 1943, Lincoln Ellison of the Great Basin Forest and Range Experiment Station, located a food cache in a snowbank on the skyline drive about 25 miles north of the general area where the five food caches, described above, were found. The items and quantity of each were as follows:

	Number	*Weight (grams)*	*Percentages*
Onion grass (*Melica*)	19	2.00	*1*
Tuber starwort (*Stellaria*)	58	23.18	*7*
Peavine (*Lathyrus*)	35	3.11	*1*
Springbeauty (*Claytonia*)	302	248.91	*82*
Saxifrage (*Saxifraga*)	44	8.09	*2*
Indian potato (*Orogenia*)	58	18.08	*6*
Miscellaneous stems	11	0.05	—

These winter stores differed from the underground caches mainly in the variety of food stored, although one contained a pure collection of dandelion roots. The last cache was interesting in that the gopher had previously gathered these millions of seeds and stored them underground, later to transport them into a snow tunnel encased in a clay covering. The collecting of ripened seeds as a source of food is evidently a rare occurrence with these gophers. Why the seeds were gathered and stored, and later thrown out in a winter core is difficult to explain.—C. M. ALDOUS, *U. S. Fish and Wildlife Service, Ogden, Utah.*

PORCUPINE DAMAGE TO BIGHORN SHEEP

In seeking for the factors that keep down the population of mountain sheep, a single instance of porcupine damage has been noted. On October 11, 1944, I found the skull and a few bones of a bighorn ewe (*Ovis canadensis nelsoni*) with porcupine quills embedded in a small patch of skin remaining on the forehead. The animal had been eaten by predators, but there was no certain evidence on the rocky ground whether the actual killing had been by a coyote or a bobcat.

This relic was discovered in Hidden Forest Canyon, in the heart of the Sheep Mountains, and on the best bighorn area of the Desert Game Range, about 50 miles north of Las Vegas, Nevada. It would scarcely be worth recording where porcupines are common, but in thousands of miles of travel in these mountains during 1942–44, neither I or my associates ever saw a living porcupine. There is occasional evidence of porcupine damage in the western yellow pine belt that straggles from about 6,500 feet to perhaps 8,500 feet elevation in the moister canyons. In 1943 we saw remains of a dead porcupine in a wash some 30 miles to the north, and in 1942, I saw one 40 air line miles to the west, on the head of Cold Creek in the Spring Range. With me were two old time residents of long experience, and they had never before seen a porcupine in southern Nevada. I saw another in 1943 at night, along the Cold Creek road, several miles down in the desert.

Neither in literature nor in reports from western out-door professionals have I found many records of porcupine damage to game, although damage to livestock is common. There is no doubt that predators suffer much damage from this source and occasional fatalities. Mountain sheep exhibit a peculiarly playful pugnaciousness. One can imagine a sheep weaving and dancing up to a porcupine, then being slapped across the face and perhaps blinded, to become an immediate victim of medium-sized predators. The instance here recorded may have been rare. In an area where porcupines are common, quill damage *could* be a controlling factor. Here among the desert bighorns, however, we are sure that the sheep are limited by another condition (non-breeding) but on the northern bighorn ranges, porcupines could take their toll, along with disease and malnutrition.—ALBERT VAN S. PULLING, *U. S. Fish and Wildlife Service, Las Vegas, Nevada.*

NEWS NOTES

William H. Marshall has become Associate Professor of Entomology and Economic Zoology at the University of Minnesota and will be in charge of work in wildlife management and conservation. He previously had seven years of field work with the U. S. Fish and Wildlife Service in the Rocky Mountains on biological investigations and also was with the United States Forest Service in New England, Arkansas, and California.

Gustave Prevost, Quebec Biological Bureau, Universite de Montreal, Montreal, Canada, wishes to purchase copies of the 15th to 19th Transactions of the American Game Conference.

Ben O. Osborn, since January 1, 1945 has been serving as "ranch conservationist" for the Soil Conservation Service at San Angelo, Texas, working with cooperating ranchers in three soil conservation districts. He reports considerable local interest in the small populations of deer, turkey, and quails (two species), and of pond and stream fish, but there is need to develop effective management programs.

The American Society of Mammalogists issued on August 1, 1945, a "Twenty-year Index to [the] Journal of Mammalogy, 1919–1939," covering volumes 1–20. This was prepared by a special committee and edited by Viola S. Schantz and Emma M. Charters of the U. S. Fish and Wildlife Service. The index comprises a single alphabetical sequence of entries by author, subject, genus and species, and state or province. The introductory pages explain the kinds and arrangement of entries. The subject entries include anatomy, disease, genetics, habits, pelage, and miscellaneous subjects, all with numerous subdivisions. The abbreviations for these and for geographic references are all listed in the introductory pages.

Elliot Coues once wrote that a good bibliographer was an inspired idiot, and those who have labored with an index probably hold similar views of their efforts. Users of this index, however, will have higher regard for and be supremely grateful to the many members who brought the work to successful completion and publication. It now will be possible to run down all of the references to a species, wherever located in the original articles in the Journal of Mammalogy.

An increasing interest in the rearing of fish in ponds and lakes is indicated by the appearance of several articles on this topic; some of the more recent are "Management of farm fish ponds" by H. S. Swingle and E. V. Smith (Alabama Poly. Inst. Agric. Exp. Sta. Bul., 254, 23 pp., illus., 1942); "Management of small artificial lakes . . . " by George W. Bennett (Illinois Nat. Hist. Surv. Bul., 22: 355–376, 1943); "Technics of fish management" by Lawrence V. Compton (U. S. Dept. Agric. Misc. Publ., 528, pp., 1943), and "The fish pond" by Clarence D. Flynt (privately published, Meridian, Miss., 41 pp., 1945).

In looking forward to the adjustment from war to peace, and contemplating the need for a central clearing house for employment in the wildlife field, the Employment Committee of The Wildlife Society has been revived and a new list of applicants for employment is being prepared. Letters have been sent to all state fish and game departments and all appropriate federal agencies inviting them to list positions for which they are seeking trained personnel. Within a few months, the Congress is expected to appropriate additional funds for the Federal Aid program and other essential activities discontinued during the war. Hence the Wildlife Society should help to bring prospective employers and employees together. Before the war the Committee had about 300 applications and was able to place many trained workers in suitable positions. The membership of the Society is urged to seek such assistance from the Committee as can be rendered.

The current committee includes: A. M. Day, Chairman, U. S. Fish and Wildlife Service, Chicago 54, Ill.; I. T. Bode, Missouri Conservation Commission, Jefferson City, Mo.; L. W. Swift, U. S. Forest Service, Washington, D. C.; W. R. Van Dersal, Soil Conservation Service, Washington, D. C.; L. W. Wing, Washington State College, Pullman, Wash.

Application blanks are available by mail from Chairman A. M. Day, on which candidates may list their training, experiences, and other essential qualifications for consideration by the Committee.

EDITORIAL

The invention of printing was a great boon to intelligent humanity in making possible the wide diffusion of knowledge, but the advent of mimeographing has been a mixed blessing. Mimeographed material confounds librarians and bibliographers as to its status in respect to "publication." Much printer's ink has been spread in debating what properly constitutes publication, particularly as to the formal description of new species; some also should be expended in respect to mimeographed reports.

The increase of interest in wildlife management during the past 15 years is reflected in the many investigations dealing with a wide variety of species and topics relating to conservation. For the information of his superiors, each worker is usually required to file reports on his studies, interim and final.

In government agencies there is a tendency, however, to consider the preparation and limited distribution of such final reports as the terminal responsibility. "Editions" of 50 to 200 copies often are mimeographed and mailed to other governmental offices or employees, sometimes also to related state agencies, and less often to certain investigators having special interest in the subject matter. Thenceforth such reports are often cited in terminal bibliographies of published articles as though part of the general literature—which they are not! This practice rests upon a mistaken premise. The results of investigations conducted at public expense, if worthy of being made and reported, should be placed on record in printed documents of general distribution and availability. It is beside the point to argue, as often done, that funds cannot be had for publication. If the expenditure of funds for such investigations is justifiable, there is an equal justification—and an obligation—that the results be made available to the public which pays for the study, or at least to that fraction of the public especially interested.

Results of investigations by the agricultural experiment stations, supported at public expense on federal and state funds, are published in series maintained by the stations, in general scientific periodicals, and in the trade and popular journals. The results from many government, university, and private laboratories similarly are put into print. In like manner, the increasing number of reports on investigations relating to wildlife, or at least the essential materials and results, should be printed in documents of general circulation and availability.

In a new field, like that of wildlife management and conservation, and with many new authors, there is a general tendency or desire to record all of the raw data and many trivial or unessential details. By contrast, current papers in older disciplines such as chemistry and physiology are notably concise in form and expression. They include only sufficient raw data or summaries thereof to support the arguments or conclusions. This is a practice deriving in part from necessity because of the many investigations and multitude of individual contributions; but it redounds to the benefit of interested readers who may glean the essential results in a minimum of wordage. Were the same true of writers and articles in the wildlife field, the need for large mimeographed reports would largely disappear, and the average student or investigator would have a more useful body of determined fact and findings available. As of today, there is a limit to the publication facilities in wildlife affairs. Terser expression would afford more ideas per unit number of words, and would afford opportunity to print much of the good and useful materials now partly or largely hidden in mimeographed reports of limited circulation and availability.

—Tracy I. Storer.

REVIEWS

Fisheries resources of the United States. Prepared by U. S. Fish and Wildlife Service. (79th Congress, 1st Session, Senate Document No. 51). 3+iv+135 pp. illus. 4°. 1945. Supt. of Documents U. S. Govt. Printing Office, Washington 25, D. C. 40 cents.

This summary was prepared under Public Law 302, 78th Congress, May 14, 1944, and according to transmitting letters by Secretary Ickes and Director Gabrielson serves to "distill," from a mass of statistical, biological, and industrial data, the essential facts about our aquatic resources and their conservation.

The text is brief but terse and informative. The graphic illustrations are modern and unconventional—partaking of advertising layouts and cartoons; they follow no set pattern but show variously the species, their distribution, the fisheries, and often the fishing methods employed. Each is specially designed to set forth the salient points of the fish or fishery involved. Besides fishes proper (Pisces), there is attention to turtles and frogs, crustaceans and mollusks, and fur seals, and even mention of pond fish culture and of sponges and seaweeds. The tunas and their allies are dealt with on a worldwide basis, and other fishes are grouped for the Pacific, Atlantic, offshore, coastal, freshwater, and Great Lakes regions. All manner of biologists from Ph.D.'s to bait-cutters will profit by reading and "digesting" this document, which also may help to make friends and influence people in legislative circles. No one previous publication of comparable size has brought together so general a review of our economic fisheries as a basis for considering matters pertaining to proper management.—TRACY I. STORER.

Reptiles and amphibians of Minnesota. W. J. Breckenridge. Minneapolis, Univ. of Minnesota Press. xiii+202 pp. 52 figs. 1944. $2.50.

This convenient local manual describes and figures the species properly accredited to Minnesota, giving also the geographic races and the range, habits, and breeding habits. With each account is a map of records within the State and a smaller inset shows the general range of the species. There is also a hypothetical list. Besides new information, the literature (6 pp. bibliography) has been culled for data. The prefatory pages discuss tales of these animals, the generalities of their geographic distribution in Minnesota, field and museum methods, care of captives, and the venomous snakes. Keys provide for identifying adults of species in Minnesota and bordering states.—TRACY I. STORER.

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